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The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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Cast Irons under Heat

Only one Paper of interest to foundrymen was presented to the May meeting of the Iron and Steel Institute, dealing with the behaviour of five cast irons under creep and growth at elevated temperatures, by Mr. Tapsell, Dr. Becker and Mr. Conway of the National Physical Laboratory. For some years past a Committee on the Behaviour of Materials at High Temperatures has been carrying out creep tests on ferrous and non-ferrous materials, in view of the tendency to the increased use of high temperatures in steam plant. This Paper is the first report issued from this Committee on cast irons, and it forms the best collection of data on the subject from any source in any country. The results will have to be read with proper discretion. For instance, five irons were tested, a straight engineering iron and a low-alloy iron, together with three heat-resisting irons, two of which are austenitic. These latter irons are intended for, or at any rate are applied usually to, cases where temperatures are comparatively high, about 850 deg. C., and the bulk of the tests in the Paper have been done at lower temperatures, maximum 538 deg. C., of interest to the users of modern steam plant.

It is well known that austenitic irons can be perfectly stable at higher temperatures and yet be subject to a certain amount of structural change at lower temperatures. Furthermore, at the lower temperatures, in ordinary irons, where there is risk of growth, this growth comes about from the breakdown of carbide to iron and graphite. This limits growth to a low figure, and the further stage of oxidation of the iron goes on only very slowly. Nevertheless, under high temperature working the resulting oxidation of ordinary irons is likely to lead to much greater dimensional changes, and growth is more serious. It is here that the special iron comes in, rather than at the medium temperatures. Creep may be regarded as deformation resulting from stress proceeding over a period of time at elevated temperatures. The higher the temperature and the greater the stress, the greater is the deformation. While creep is a problem in modern turbine plant, there are many applications at high temperatures in which actual creep is of slight practical importance. Nevertheless, the data furnished make it possible for users to compare one iron with another and enable designers to design castings on an intelligent basis, according to the stresses and temperatures involved. Creep data are not easy to follow, but they are of value to those who are skilled in their application, and when it is remembered that only five or six years ago these special irons were practically unheard of, the development is remarkably rapid.

A Pro-Tempore Solution

It is about a year and a half ago since Mr. C. E. Williams wrote to us asking if it were known which was the oldest cast-iron casting still existing to-day. This search, which has encompassed the world, now needs a set of rules governing the award of "extremest antiquity." Should, for instance, the casting bear a date, or is normal antiquarian reasoning accepted, or finally is an authentic literary reference desired which would establish the genesis of the art? Much evidence germane to all three questions has been adduced by Mr. Thomas T. Reed and printed in the last issue of the "Iron Age" to reach England. The interesting fact has emerged that one of the oldest "dated" castings is also thought to be the largest one ever made. It is an art casting of a lion carrying a sphinx-like head, cast in 953 A.D. It is 20 ft. high and about 18 ft. long. It is supposed to be a plinth for carrying either a statue of Buddha or Bodhisattva, more probably the former.

A point worth raising is that of the first cast-iron cannon. Mr. Reed illustrates a Chinese one dated 1377, but Mr. P. H. Wilson has given a literary reference to one made in 1313 A.D., by a Belgian foundry, but apparently no evidence is available of its existence to-day. The oldest dated casting so far found was made in 615 A.D. It is a sacrificial bowl shaped like an incense burner, and stands in the yard of the Yü-ch'üan temple in Tang-yang-hsien, Hupei. It is about 3 ft. high and 4 ft. in diameter, with four human figures as legs.

Antiquarian research has established that a flourishing cast-iron foundry industry existed in China from 206 B.C. to 221 A.D., whilst the very earliest reliable literary reference to cast-iron castings is 513 B.C.—a thousand years before the first dated one. It was a one-off job for a vessel on which the criminal code was to be inscribed, and about 6 cwts. of iron was required for it. The birth of the art of making iron castings most probably took place in a period of universal illiteracy.

It is thus established that the idea that this art was invented in Europe in the 14th century is erroneous, and the cast-iron statuette of a man in the Barbican at Lewes examined by the late Sir W. C. Roberts-Austin is most probably an authentic example of a Roman art casting, possibly made something over 1,000 years earlier. For the moment, Mr. Williams's query is answered by (dated) 615 A.D., (authenticated but undated) *circa* 200 B.C., and (authenticated literary reference) 513 B.C.

Correspondence

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Stainless Steels

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—On glancing through the Editorial which appears in this week's issue of THE FOUNDRY TRADE JOURNAL, and relates to a Paper which I recently gave before the Institution of Production Engineers, I was somewhat startled to find the following statement attributed to me:—

"In 1892 Sir Robert Hadfield published experiments on the addition of chromium up to 16 per cent., but did his corrosion experiments in nitric acid."

Referring to my Paper, page 59, lines 19 to 22, I find that my actual words were as follow:—

"In conducting his experiments, however, he did *not* use nitric acid and therefore it may be considered as unfortunate that he omitted those critical tests . . ."

I think you will agree that there is some slight disparity between my statement and your report.

Yours, etc.,

W. H. HATFIELD.

Atlas and Norfolk Works, Sheffield, 1.
May 9, 1936.

[We very sincerely regret this unaccountable *lapsus memoriæ*.—EDITOR.]

Motor Cylinder Bore Wear

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In reply to Mr. G. D. Pincott, I beg to point out that his summing up is entirely wrong: (*a*) The poor quality cylinder block does not belong exclusively to the outside foundries. I know of foundries attached to engine builders which have produced cylinder block castings correctly described as rotten, when viewed from the point of service given, but they have always endeavoured to profit by experience of this sort. (*b*) The responsibility for the poor cylinder block does not rest entirely with the buyer, but rather with the foundry manager. This is why I suggested that a full and free discussion between the buyer and the manager of the foundry from which he obtains his supplies would be to their mutual benefit. (*c*) The usual chemical specification allows of too wide a variation in the percentage of the various elements; on the other hand, the physical test figures are more than sufficient to meet the requirements of the car manufacturer, but how often are these tests taken? I am sure Mr. Pincott will agree that it is practically impossible for the inspection department to carry out their tests on cylinder blocks passing through production; I believe that if one of these physical tests could be applied to each casting passing through the machine shop over 50 per cent. would fall well below the specified figure, as both the buyer and the inspection department are very largely in the hands of the various foundry managers, so let us be as honest as we possibly can with all of them.

Changes in Methods and Materials.—It is due to my experience over many years' practice operating with materials and using many different analyses, that I suggested the analysis given. I have every confidence that the analysis indicated will give excellent results if combined with good foundry practice. With regard to changes in methods, I plead guilty to altering it whenever (after due thought) I felt convinced that it would show improvement either in quality or cost, or both. This is where the car manufacturer's foundry is able to indulge in a little research of its own, for the benefit of the job generally. This should also be of some service to outside foundries, because they have the opportunity of knowing what is being done. I agree that we must always be careful in making changes; also that it is a wise policy to leave well alone; but we must be quite sure that what we are leaving alone is well. The buyer does hold part of the responsibility for reasons stated, but not by virtue of placing orders with outside foundries; personally, I regard the outside foundries as the backbone of the British foundry industry. These, in their efforts to improve quality, have my best wishes, and the buyer must see they have a fair quantity of orders to justify them in carrying on with development of methods and quality.

Phosphorus Content.—On this we are agreed, and also in regard to local porosity, the bulk certainly has to be taken into account in compiling the analysis; but local porosity is due to a much greater extent to foundry practice than to the metallurgist. While some foundries have great difficulty in producing sound castings if the phosphorus content exceeds 0.3 per cent., others will run the same job quite satisfactorily with 0.5 to 0.6 per cent., and a prominent advertisement in THE FOUNDRY TRADE JOURNAL shows a sectioned cylinder block which was run with 0.7 per cent. Finally, my own desire is to render what assistance I can to the foundry industry generally, and I am quite sure Mr. Pincott is actuated by the same motive.—Yours, etc.,

A. SMITH.

[This letter has been slightly abbreviated.—EDITOR.]

Publication Received

Contemporary Pewter in the Netherlands. Being Bulletin No. 3 of the International Tin Research and Development Council, Manfield House, 378, Strand, London, W.C.2.

There is not a large quantity of text in this admirable brochure, but the one statement likely to be disputed by a section of the trade is whether pewter manufactured from sheet is the genuine article. This book supports the contention that sheet may be used, whilst the only British craftsman we have ever met insists that to be genuine pewter must be cast and that the craftsman must have a casting as his raw material. Whilst pewter lends itself splendidly to the production of *objets d'art*, yet for this brochure, equal approbation must be given to the sister art of photography, for seldom have we seen a better example of the art of illustration. We are promised further publications dealing with the pewter of other countries, and to these the whole of the artistic side of the foundry industry will look forward with considerable interest. If they do but emulate the one under review, a collection of superlative merit will become available for reference. This bulletin contains 66 pages and the major portion is devoted to illustration.

Book Review

An Introduction to the Metallurgy of Iron and Steel. By H. M. Boylston, B.S., A.M., Met.E., Professor of Metallurgy, Case School of Applied Science and Consulting Metallurgical Engineer.—Published by John Wiley & Sons, Inc., New York. London: Chapman & Hall, Limited, 11, Henrietta Street, Covent Garden, W.C.2. Price 25s. net.

In this book Prof. Boylston has endeavoured to present an introduction to a very broad and highly technical profession, which, as he himself says in the preface to the first edition, no brief volume can easily cover. It is addressed to students in engineering schools and in evening schools, and to men who work in steelworks.

On reading through the book it is hard to realise that it is being published as late as 1936, because the contents carry one little further forward than do those of textbooks published twenty years ago. Many matters of great importance, with which students and practical men should be acquainted, are ignored altogether, or only cursorily dealt with, while at the same time, the book contains a lot of unnecessary, and generally speaking, inaccurate details.

It is difficult to conceive what use an historical section can be to a young student. When the facts are wrong it is worse than useless; it is misleading. The statement that the Delhi Pillar appears to be made up of lumps of wrought iron weighing about 80 lbs. each is incorrect. The most detailed examination of the surface of this pillar does not afford any clue to warrant such a deduction. The details concerning crucible steel manufacture are quite unnecessary and not representative of American, English or Continental practice. For instance, the statement that clay pots are not as strong as graphite pots is incorrect. Clay pots when hot are much stronger than graphite pots, but when cold graphite pots are the stronger. The process of killing by fire is described. This is a process which, to all intents and purposes, was abandoned many years before the virtual decease of the crucible process itself. The details of the working of crucible steel are also inaccurate and misleading. The author says that the upper end of the ingot is cropped to remove piping and the impurities that rise to the top when the metal is fluid, and then goes on to state that the cropping is taken to the laboratory and analysed. Such a procedure would, of course, be ridiculous. The suggestion that ingots are brought to welding heat and then hammered to weld up all internal perfections would certainly be strongly contested by metallurgists.

In spite of devoting several pages to a description of the now practically defunct crucible process, only one page is devoted to a consideration of high frequency electric furnaces, which reached a high stage of perfection several years ago, and appear as if they will eventually supersede all other electric melting processes.

The chapter dealing with the effect of various elements on the properties of steel is inadequate, even for an elementary textbook, and the author does not appear to be at all sure of his facts. The statement that cobalt steels are not in common use is incorrect. Cobalt steels have been used extensively for the last twenty years. The suggestion that this metal is only used in high-speed steel up to about 4 per cent. is likewise incorrect. That percentage of cobalt had already been used in high-speed steel before the European War and modern high-speed steels frequently contain from 10 to 15 per cent. cobalt. There is also no doubt about the effect of cobalt on the magnetic properties of steel, but Prof. Boylston contents himself with saying that a 35 per cent. cobalt magnet steel is "said to be far superior to any previous type." Cobalt magnet steels have been known to be superior to all other types of magnet steel for the last fifteen years, and thousands of tons have been manufactured.

(*Concluded from next column.*)

Chromium steels play a most important part in present-day engineering, and yet this section is also treated inadequately, as are all the other sections in the chapter.

On page 413 the author describes a type of alleged blue brittleness. On page 456 a completely different phenomenon is described under the sub-heading "Blue Brittleness," which expression is again repeated in the text. In this section the suggestion is that Krupp Krankheit and blue brittleness is one and the same phenomenon. Krupp Krankheit is, of course, an obsolete term for what is now usually called temper brittleness, and has nothing whatever to do with blue brittleness.

Whatever little value the book may have had as a work of reference is still further depreciated by the inadequacy of the index. In it, there is, for instance, no reference to magnet steels, the use of aluminium, Momax high-speed steel, killing, dead-melting, etc., etc., all of which are dealt with in the text.

J. F. K.

(*Concluded in previous column.*)

The Iron and Steel Institute

ANNUAL MEETING IN LONDON

The Annual Meeting of the Iron and Steel Institute was opened on Thursday last at the Institution of Civil Engineers, Great George Street, Westminster, London, Sir H. C. H. Carpenter, F.R.S. (President), in the chair.

Royal Patronage of the Institute

The Report of the Council states that they are proud to announce that His Majesty King Edward VIII has been graciously pleased to become Patron of the Institute.

The following letter was, by order of the Council, addressed to the Rt. Hon. Lord Wigram of Clewer, P.C., G.C.B., G.C.V.O., C.S.I., Keeper of the Privy Purse:—

March 25, 1936.

MY LORD,

We are desired by the Council of the Iron and Steel Institute to ask you to submit to His Majesty King Edward VIII a humble and loyal request that His Majesty will be graciously pleased to honour the Iron and Steel Institute by consenting to become its Patron.

The Council of the Iron and Steel Institute in submitting this request recall with pride that His Majesty has been an Honorary Member of the Institute since 1919.

His Majesty King Edward VII and His Majesty King George V honoured the Institute by becoming Patrons, and they were also graciously pleased to accept the Bessemer Gold Medal in 1906 and 1934 respectively, while Her Majesty Queen Victoria was also graciously pleased to accept the Bessemer Gold Medal in 1899.

In transmitting this request we are desired to ask you to assure His Majesty of the loyalty and devotion of the Members and Council of this Institute.

We have the honour to remain,

Yours faithfully,

(*Signed*) H. C. H. CARPENTER,
President.

(*Signed*) KENNETH HEADLAM-MORLEY,
Secretary.

The following reply was received:—

Privy Purse Office,
Buckingham Palace, S.W.
April 6, 1936.

DEAR SIR,

I am commanded by The King to inform you that His Majesty has been graciously pleased to grant his Patronage to the Iron and Steel Institute.

Yours truly,
(*Signed*) WIGRAM,
Keeper of the Privy Purse.

The President,
The Iron and Steel Institute,
28, Victoria Street, S.W.1.

Report of Council

The Report states that during the past year 104 members and 17 associates were elected; seven associates were transferred to membership, and six members were reinstated. Forty-two members and one associate resigned their membership during the year. The total membership of the Institute on the register on December 31, 1935, was accordingly as follows:—Patron, 1; honorary members, 17; life members, 67; ordinary members, 1,768; associates, 62; making a total of 1,915, compared with 1,918 at the end of the previous year.

Referring to the deaths of 28 members of the Institute which occurred during the year 1935, the Council state that they wish to place on record their regret at the death, after illness lasting for many years, of Mr. Percy Carlyle Gilchrist, F.R.S. Mr. Gilchrist's name is honoured throughout the world for his work, in conjunction with his cousin, Mr. Sidney Gilchrist Thomas, on the invention of the basic process of steelmaking, the success of which was first established at the works of Messrs. Bolckow Vaughan & Company, Limited, at South Bank, near Middlesbrough, in April, 1879. From their joint invention originated the basic-Bessemer and the basic open-hearth processes of steel manufacture, by means of which an overwhelming proportion of the world's steel is now produced. Mr. Gilchrist joined the Institute in 1875; in 1884 he was elected a member of Council, in 1898 a Vice-President, and in 1916 an Honorary Vice-President. Mr. J. Neilson was the last original member of the Institute, and Sir John Field Beale, K.B.E., Mr. T. B. Mackenzie, Mr. P. J. Mitchell and Mr. H. N. Sweet were life members.

The statement of accounts for the year 1935 shows that the ordinary income of the general fund during 1935 was £8,788 16s. 9d., and the expenditure £10,721 8s. 5d., the result being an excess of expenditure over income of £1,932 11s. 8d. The receipts of the Special Appeal Fund during the year amounted to

SIR H. C. H. CARPENTER, F.R.S.
(*President of the Iron and Steel Institute.*)

£2,010, and this figure has been taken into the accounts. The accounts of the Welding Symposium, which are shown separately, show that the balance of the income and expenditure account at the end of the year was an excess of expenditure over income of £1,244 8s. 3d. Two thousand copies of the Proceedings were printed. The unsold stock of volumes has not been valued, and the proceeds of further sales will be available for reducing this sum. It is estimated that if the remaining stock is disposed of, the ultimate net cost to the Institute will be reduced to about £300; 822 sets of volumes were sold before publication in November, 1935, and 450 additional sets since then up to the end of March, 1936. Sales are continuing at a satisfactory rate.

Changes on the Council.—During the year under review, Mr. I. F. L. Elliot, Mr. E. F. Law and Dr. T. Swinden were elected members of Council. Mr. J. T. Wright succeeded Mr. H. E. Cookson as an honorary member of Council on being elected President of the Staffordshire Iron and Steel Institute, and Mr. F. Bainbridge succeeded Lieut.-Col. Wm. Routledge on being elected President of the Cleveland Institution of Engineers. Since the close of the year Mr. Henry Bond has expressed his desire to retire from the Council, and has been nominated an Honorary Vice-President, and Mr. E. J. Fox has been elected a member of Council.

In accordance with Bye-Law 10, the names of the following Vice-Presidents and members of Council were announced at the Autumn Meeting as being due to retire at the annual meeting in 1936:—Vice-Presidents: Mr. A. Hutchinson, Mr. John Craig, C.B.E., and Mr. H. Spence Thomas. Members of Council: The Rt. Hon. the Earl of Dudley, M.C., Capt. R. S. Hilton, Mr. I. F. L. Elliot, Mr. E. F. Law and Dr. T. Swinden. No other members having been nominated up to one month previous to the Annual Meeting, the retiring members were presented for re-election.

Andrew Carnegie Research Scholarships.—Grants were made by the Council in 1935 to the following candidates:—

M. ALEXANDER (University College, Swansea). £100 for the further study of the influence of gases on the position of blow-holes in steel ingots.

W. HOOK (Newcastle-upon-Tyne), £100 for a study of the pyrolysis of organic compounds with a view to determining the factors which favour graphite formation.

T. RAINE (Sheffield University), £100 for an investigation of the determination of oxygen in steel.

G. T. RICHARDSON (University of Leeds), £100 for an investigation of the influence of furnace atmospheres on steels.

J. B. VICKERS (Sheffield University), £100 for an investigation of the determination of oxygen in steel.

G. BOOTH (Refractories Department, Sheffield University), £100 for an investigation on basic refractories, with particular reference to their use in linings of induction furnaces.

R. GOODACRE and E. T. GILL (Messrs. Bruntons Research Laboratory, Musselburgh), £100 for an investigation of some aspects of the fatigue properties of cold-drawn wires.

R. MITSCHE (Eisenhütteninstitut der Montanistischen Hochschule, Leoben), £50 for the continuation of the research into the flotation of non-metallic inclusions and the application of the fluorescence microscope in the field of the non-metallic inclusions.

H. NIPPER (Institute of Foundry Practice, Aachen), £50 for a research on recrystallisation tests on ferritic cast irons.

W. W. O. RUFF (Laboratories of the Bergische Stahl-Industrie, Remscheid), £100 for a research on the running qualities of cast iron and steel under standardised pouring conditions.

A. A. TIMMINS (the British Cast Iron Research Association, Birmingham), £50 for a research on the formation and decomposition of pearlite in cast iron.

Bessemer Gold Medal.—The Bessemer Gold Medal for the year 1935 was presented to Prof. A. M. Portevin, Director of the Institut de Soudure Autogène, Professor at the Ecole Supérieure de Fonderie, and at the Ecole Centrale des Arts et Manufactures, Paris, in recognition of his contributions to the advancement of the science and practice of metallurgy.

Carnegie Gold Medal.—The Andrew Carnegie Gold Medal for the year 1935 was awarded to Dr. D. F. Marshall, of Sheffield, for his Paper entitled "Further Determinations of the External Heat Loss of Blast Furnaces."

Williams Prize.—For the year 1935 no award of the Williams Prize was made.

The PRESIDENT, in moving the adoption of the Report of the Council, including the statement of accounts, referred to the fact that the Report opened with a reference to the death of His Majesty King George V. So recently as 1934 His late Majesty showed his interest in the work of the Institute by accepting the Bessemer

Medal. Those who had had the privilege of attending on that occasion would always remember the deep interest which he showed in the Institute's work; it was a very memorable occasion for them. It would be fitting if the members stood in their places for a few moments.

The members stood in silence.

Continuing, the President said the Iron and Steel Institute was the oldest of the metallurgical societies, but there were a number of others in existence, and it seemed to the Council that the time had come when the Institute might profitably consider whether it could not do something to increase its own usefulness and that of the other societies by a policy of co-operation. The body with which the Institute was most closely connected from the point of view of membership was the Institute of Metals; there were 300 members who were common to both Institutes. It seemed to the Council that the Institute of Metals might be approached with a view to ascertaining whether there were any ways in which the two Institutes could co-operate usefully with one another. He would like to make it clear that it was not intended that there should be any interference with the independence of each Institute. Any body with which the Iron and Steel Institute entered into co-operation would preserve its identity and independence. With that reservation, the Council thought that there were many ways which might profitably be pursued in which the Institute and other bodies could support one another and give better service to their members.

Mr. F. W. Harbord, C.B.E. (Past-President), seconded the motion for the adoption of the Report.

Plan to Stimulate Membership

Mr. James Henderson (Hon. Treasurer), presenting the statement of accounts and referring to reduced income, remarked that it might occur to some members of the Institute that it might be wise, with the lesser income, to cut down the expenditure, but the Council submitted that that would be a disastrous and unthinkable course to adopt. The Institute must therefore look to a continuance of special subscriptions to assist it in its work. The Council did not overlook the fact that membership of the Institute was the best, soundest and surest source of income, and, with that in mind, he would like to give credit to Mr. Talbot, who was present at the meeting, for a suggestion whereby membership of the Institute was being promoted. Firms and companies giving special subscriptions had been invited to nominate members of their staff for membership of the Institute, it being understood that the entrance fee and first year's subscription of those members would be set against the special subscription. Thereafter, in the second and following years, those members would be responsible for their own subscriptions. Already that scheme had brought the Institute something over one hundred proposals for membership. It was hoped that the number of such members would increase as time went on, and that the scheme would stimulate interest in the Institute and increase its revenue.

Autumn Meeting at Dusseldorf

The President said that at the meeting held in Manchester he had announced that the Council had accepted an invitation from the Verein Deutscher Eisenhüttenleute, on behalf of the German iron and steel industry, to hold the Autumn Meeting in Düsseldorf. The date which had been agreed upon was from September 20 to September 27 inclusive, with an extension to September 30 for parties visiting certain other places. It was estimated that the inclusive cost of the visit would be about £20. He would ask Dr. Petersen, whom the Institute welcomed at its meeting, to convey the invitation to the members.

Dr. Petersen said that it was his duty and pleasure to convey an official invitation from the Verein Deutscher Eisenhüttenleute on behalf of the German iron and steel industry to the Institute to visit Düsseldorf and to make that their headquarters and to see all the places of interest in the neighbourhood, the gentlemen on the metallurgical side and the ladies on the other side. The President and members of the council of the Institute knew the programme that was proposed for the visit, and the German metallurgists looked forward to the honour of a visit from the Institute with pleasure and interest.

The President said he was sure all the members would wish him to thank Dr. Petersen and to assure him that the members of the Institute were looking forward very much to their visit to Düsseldorf.

Presentation of the Bessemer Medal

The President said it was his pleasant duty to make the award of the Bessemer Gold Medal, which was the highest honour that the Institute was able to confer. He felt sure that all the members would agree that in selecting Mr. Fred Clements the Council had made a wise and happy choice. Mr. Clements had been associated for many years with the Park Gate Iron and Steel Company, and there could be no doubt that he was largely responsible for the favourable position in which the company found itself to-day. He was a practical metallurgist but not one of the so-called practical men who had no use for science. He had always realised and utilised the benefits which science could confer on industry, and indeed he himself had made valuable contributions to the science of ferrous metallurgy. He asked Mr. Clements to accept the Medal as a token of the Institute's appreciation of the services he had rendered to the iron and steel industry.

Mr. Fred Clements
(Bessemer Gold Medallist).

Mr. Fred Clements was born on January 4, 1882, at Chesterfield, and educated at Dronfield Grammar School. In 1896 he commenced as an apprentice at the works of Messrs. Markham & Company, Limited, Chesterfield, and passed through the shops and drawing office. In 1903 he was sent by the late Mr. Charles Markham to take up a junior position on the engineering staff of the Park Gate Works. Mr. Markham was a director of the Park Gate Iron & Steel Company, Limited, and Mr. Frank Dick was at that time general manager. In 1905 Mr. Clements gained the Whitworth Medal and Exhibition. Until 1923 he was engaged at Park Gate in positions of increasing responsibility in the design and installation of blast furnaces, open-hearth furnaces and rolling-mill plant, and in that year was appointed general manager of the company. He was then responsible for the operation and organisation of the firm's activities. In 1935 he was appointed a director. During the immediate post-war period he was interested in carrying out exhaustive research work on actual operating examples under works' conditions. The results were communicated to the Iron and Steel Institute in the following Papers:—"British Blast Furnace Practice" (1920), "British Siemens Furnace Practice" (1922), "British Gas Producer Practice" (1923). In 1929 he published "Blast Furnace Practice" in three volumes, its preparation taking five years. He is a member of the Iron and Steel Industrial Research Council of the British Iron and Steel Federation and is chairman of its Blast Furnace Committee. He acts as a consultant to a number of large producers of pig-iron and has contributed articles to the last edition of the Encyclopædia Britannica. He is a member of the Council of the Iron and Steel Institute and is also a member of the Institution of Civil Engineers, the Institution of Mechanical Engineers, and other societies in this country and in America.

Mr. Clements said he felt it was quite impossible for him to express adequately his appreciation of the very great honour the Institute had conferred upon him. As he recalled the names of those who were enrolled upon the list of Bessemer Medallists, he felt very proud of the fact that he had been deemed worthy to join their ranks. The speaker went on to refer to incidents in his career, and paid a grateful tribute to his late chief, Mr. Charles Markham. He could, he said, conceive of nothing which would have given greater pleasure to Mr. Markham than to know that one of his boys had been deemed worthy to receive the Medal.

Proceeding, Mr. Clements said he would like to speak to the younger members of the Institute. He would like to call their attention to the great fields that had still to be investigated, and he would say that at no time in no country and in no industry had there ever been the opportunities that there were to-day in the iron and steel industry. But opportunity like the pearl of great price did not come unsought. It was the reward of the earnest seeker. At the same time he would like to say to those present who were the executive heads of large firms: Do not quench the spark of original thought or effort in any of your people. Original thought was too uncommon for anyone to do that. The spark, such as it was, might come in unexpected places. It should be shielded with sympathy and fanned with the breath of encouragement. If it was false it would die; if it was true it would live and glow and might set alight a blaze in the world of thought.

He accepted the Medal, not only in his own name, but in the name of all those who were trying by spending themselves, by labour of mind or labour of body, to increase and improve the technical progress of the great world-wide iron and steel industry, for it was to them as well as to himself that he deemed the award to be given. In their name and in his own, he said, with all sincerity: We thank you.

Annual Dinner

The Annual Dinner, over which Sir Harold Carpenter presided, was held at the Connaught Rooms last Friday. The principal speakers were Mr. Duff Cooper, Minister of War; Sir William Larke; Mr. John Craig and the Earl of Crawford. Amongst those present who are prominent in the foundry industry were:—J. S. Kerr; J. A. Smeeton; H. B. Toy; S. V. Toy; Dr. L. B. Pfeil; A. C. Turner; J. W. Gardom (Chairman of the Technical Committee of the Institute of British Foundrymen); C. H. Kain; Dr. A. B. Everest; A. B. Winder; A. A. Fellows; J. Crawford; G. Clayton; Prof. J. H. Andrew; Dr. A. McCance; P. B. Brown; W. J. Dawson; W. R. Barclay (President, Institute of Metals); G. T. Lunt; E. P. Taudevin; N. Van Marle; Major F. A. Freeth (President, British Cast Iron Research Association); Prof. R. Hay; Prof. D. Hanson; Dr. T. Swinden; T. M. Service; D. F. Campbell; Barrington Hooper, C.B.E. (Managing Director, The Foundry Trade Journal); K. Headlam-Morley (Secretary, Iron and Steel Institute); O. Wass; R. A. Kirkby; G. Senior; E. P. Page; A. N. McQuistan; A. Firth; T. C. Firth; T. Henry Turner; W. E. Dobson; K. H. Gloag; A. G. Robiette; H. Jeans (Chairman, The Foundry Trade Journal); P. Jump; H. E. Cookson; H. Shillitoe; J. G. Pearce (Director, British Cast Iron Research Association); V. C. Faulkner (Past-President of the Institute of British Foundrymen, Editor of The Foundry Trade Journal); H. W. Lockwood (Hon. Secretary of London Branch of the Institute of British Foundrymen); Prof. Thomas Turner; E. J. Fox; J. E. Hurst (President, Institute of British Foundrymen); Prof. F. C. Thompson; V. Delport (President of the London Branch of the Institute of British Foundrymen).

Behaviour of Five Cast Irons in Relation to Creep and Growth at Elevated Temperatures*

By H. J. TAPSELL, A.C.G.I., M. L. BECKER, Ph.D., B.Met., and C. G. CONWAY, B.Sc. (National Physical Laboratory)

It appears to be generally considered that ordinary cast iron is serviceable only at comparatively low steam temperatures, owing largely to dimensional changes at higher temperatures, *i.e.*, "growth," accompanied by loss of strength. In Great Britain the general view appears to be in favour of limiting the use of ordinary cast iron to a maximum steam pressure and temperature of 250 lbs. per sq. in. and 400 deg. Fah. respectively. According to the Boiler Code of the American Society of Mechanical Engineers, the use of cast iron for pressure-containing parts is limited to a maximum temperature of 450 deg. Fah.

Some short investigations† have been made of the creep and growth of ordinary cast irons at temperatures below the critical range, but so far as the authors are aware the comparative growth/time characteristics of ordinary and alloy cast irons in the steam temperature range of 700 to 1,000 deg. Fah. have not been demonstrated, and no data relating to the comparative creep properties of the irons in that temperature range have appeared in the literature.

The work described in this Paper was, therefore, undertaken with a view to determining to what extent ordinary and alloy cast irons have useful properties at high steam temperatures, and whether they are capable of further application at these temperatures. Five typical irons were selected in consultation with Mr. J. G. Pearce, director of the British Cast Iron Research Association, who kindly arranged for the supply of material.

The materials were:—Ordinary grey cast iron, nickel-chromium iron, Silal, Nicrosilal and Niresist. In the main, the creep and growth tests have been carried out within the range 700 deg. Fah. (370 deg. C.) to 1,000 deg. Fah. (538 deg. C.), but the results of some comparative tests at 850 deg. C. on the high-alloy irons have been added to the Paper. A study has been made of the microstructures of the irons as tested, and of the modifications produced by prolonged heating at the testing temperatures.

The work was of an exploratory nature, and was discontinued when it reached a stage which, it was thought, had provided results which might encourage industry to proceed with further research on parallel lines.

TABLE I.—*Chemical Composition of the Cast Irons.*

	Ordinary.	Nickel-chromium.	Silal.	Nicrosilal (1st batch).	Nicrosilal (2nd batch).	Niresist.
T.C., per cent.	3.29	3.19	2.39	1.75	1.80	2.44
Gr. carbon, per cent. ..	2.19	2.54	2.31	1.47	1.53	1.70
C.C., per cent. (by difference)	1.10	0.65	0.08	0.28	0.27	0.74
Si, per cent.	1.27	2.13	5.72	5.84	4.43	1.11
Mn, per cent...	0.28	0.58	0.67	0.68	0.60	0.76
S, per cent.	0.12	0.090	0.063	0.039	0.046	0.057
P, per cent.	0.72	0.80	0.30	0.045	0.036	0.26
Ni, per cent.	—	0.67	—	17.72	18.67	16.56
Cr, per cent.	—	0.34	—	2.10	2.56	3.30
Cu, per cent.	—	—	—	—	—	7.30

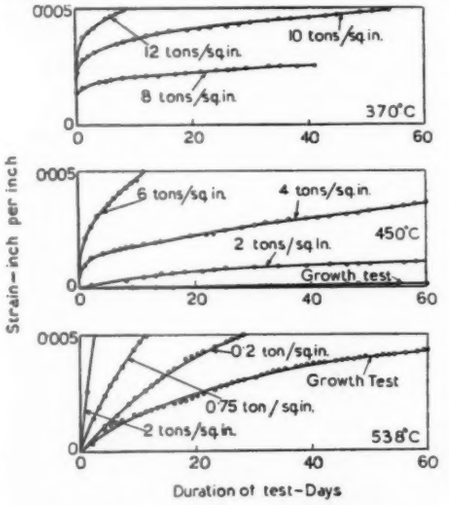

FIG. 1.—STRAIN/DURATION CURVES FOR ORDINARY CAST IRON.

Materials Examined

Cast bars, approximately 1.2 in. in dia., of each of the five irons were obtained by arrangement with Mr. J. G. Pearce, director of the British Cast Iron Research Association. The chemical composition of the irons is given in Table I. The ordinary cast iron was supplied as being typical of a good engineering iron, but the combined carbon content was unusually high. It was probably rather hard, but this, it was believed, was in line with modern tendencies. The nickel-chromium iron was also typical of an improved high-class iron, and the particular composition was considered to be suited for rather thinner castings than the ordinary iron. The sample of Silal iron contained slightly more carbon than was usually considered desirable, and the phosphorus content was above the usually recommended value. Experiments with the first batch of Nicrosilal iron indicated that its composition was rather critical, and a second batch of slightly different composition was briefly examined at the suggestion of Mr. J. G. Pearce. The Niresist iron was probably fairly typical in composition, but the carbon and manganese contents were somewhat lower than the values recommended by certain authorities.‡

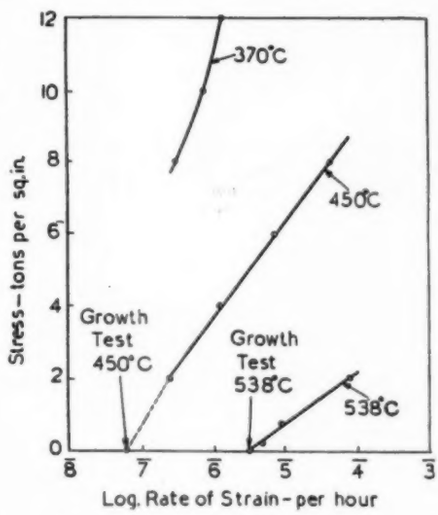

FIG. 2.—STRESS/LOG. RATE-OF-STRAIN CURVES FOR ORDINARY CAST IRON.

The microstructure of the irons in the as-received condition is described in conjunction with the changes occurring during creep and growth tests under the appropriate headings below.

Bend Tests at Air Temperature

To provide an indication of the quality of each of the irons a few bars were subjected to the transverse bend test. The unmachined test bar, approximately 1.2 in. in dia., was rested on cylindrically seated blocks 18 in. apart, and was gradually loaded at the centre of the span, the loading die being 2.5 in. in dia. Readings of the deflection were taken during loading in order to determine the maximum deflection at fracture. At least two tests were made on each iron, and the results are shown in Table II.

TABLE II.—*Results of Bend Tests.*

Material.	Mean diameter of test bar. In.	Rupture load. Tons.	Modulus of rupture. Lbs. per sq. in.	Maximum deflection at fracture. In.
Ordinary iron	1.20	1.05	62,400	0.167
	1.28	1.00	48,800	0.138
	1.27_5	0.81	40,350	0.097
Nickel-chromium iron ..	1.22_5	1.166	65,130	0.155
	1.23_5	1.40	76,300	0.180
	1.24	1.285	68,800	0.184
Silal iron	1.20	1.10	65,400	0.172
	1.23	1.10	60,750	0.201
Nicrosilal iron (1st batch) ..	1.22_5	0.96	53,740	0.60
	1.22_5	0.965	53,900	0.45
Niresist iron	1.22_5	0.88	49,015	0.17
	1.25	1.00	52,560	0.21

Certain bars were found to contain blowholes, and others were somewhat porous; some variation

* Abstracted from a Paper presented before the annual meeting of the Iron and Steel Institute in London last week.

† Honegger, "Das Gusseisen," Eidgenössiche Materialprüfungsanstalt an der E. T. H. in Zürich. Diskussionsbericht Nr. 37. Zurich: December, 1928.
E. Piwowarsky and O. Bornhofen, "Archiv für das Eisenhüttenwesen," 1931, vol. 5, pp. 163–166.

‡ J. S. Vanick and P. D. Merica, "Corrosion- and Heat-Resistant Nickel–Copper–Chromium Cast Iron," Transactions of the American Society for Steel Treating, 1930, vol. 18, p. 923.

in modulus of rupture was, therefore, to be expected, since the bend test bars were chosen haphazardly from the batches supplied. In all the further tests to be described, machined specimens were used, and only those were tested which, during machining, were found to be reasonably free from blowholes and porosity.

Short-Time Tensile Tests

Tensile tests were made at air temperature, 370 deg. C. (700 deg. Fah.), 450 deg. C. (842 deg. Fah.) and 538 deg. C. (1,000 deg. Fah.). Two sizes of specimens, 0.564 in. and 0.35 in. in dia., both of 2 in. gauge length, were used for the tests at air temperature, but specimens of 0.35 in. dia. only were used for the high-temperature tests. The 0.564 in. dia. specimens were machined from the full sections of the bars, whilst the 0.35 in. dia. specimens were machined from half sections. In all the tests, the load was applied at a rate of approximately 1 ton per sq. in. per min., and at least two tests were made at each temperature. The results of these tests are given in Table III.

For the first three irons in Table III the ultimate stresses at air temperature for the 0.564 in. dia. specimens are higher than those obtained with 0.35 in. dia. specimens, but the reverse applies in the case of the Nicrosilal iron and the Niresist iron. The short-time tensile strengths of the ordinary, nickel-chromium and Silal irons are not impaired until a temperature of 450 deg. C. (842 deg. Fah.) is exceeded; the nickel-chromium iron shows an appreciable increase in strength at 370 deg. C. (700 deg. Fah.). Both Niresist and Nicrosilal irons have low strength, but Nicrosilal exhibits the best elongation values over the range of test temperatures, whilst Niresist shows the least rate of decrease in strength with temperature.

TABLE III.—*Results of Short-Time Tensile Tests.*

Temperature of test. Deg. C.	Ultimate stress. Tons per sq. in.				Approximate elongation on gauge length. $L = 4\sqrt{\text{area}}$. Per cent.		
	Individual tests.			Average value.	Individual tests.		
	(1)	(2)	(3)		(1)	(2)	(3)
Ordinary iron.							
Air (0.564 in. specimens) ..	16.0	15.4	17.5	16.3	0.5	0.5	0.5
Air (0.35 in. specimens) ..	14.6	15.8	15.4	15.3	0.5	0.5	0.5
370 ,, ,, ..	16.6	14.9	—	15.7	1.0	0.5	—
450 ,, ,, ..	14.9	14.8	—	14.8	0.5	1.0	—
538 ,, ,, ..	8.9	10.9	—	9.9	2.5	1.5	—
Nickel-chromium iron.							
Air (0.564 in. specimens) ..	16.0	16.1	16.0	16.0	0.5	0.5	0.5
Air (0.35 in. specimens) ..	14.3	12.3	—	13.3	0.5	0.5	—
370 ,, ,, ..	16.5	16.8	—	16.6	0.5	0.5	—
450 ,, ,, ..	15.3	12.7	—	14.0	1.5	1.0	—
538 ,, ,, ..	10.4	7.2	10.7	9.4	1.0	1.0	1.0
Silal iron.							
Air (0.564 in. specimens) ..	14.4	13.4	14.8	14.2	0.5	0.5	0.5
Air (0.35 in. specimens) ..	14.3	15.1	12.3	13.9	0.5	0.5	0.5
370 ,, ,, ..	11.4	15.8	—	13.6	0.5	0.5	—
450 ,, ,, ..	16.2	11.3	15.2	14.2	1.0	0.5	0.5
538 ,, ,, ..	8.6	9.1	—	8.8	1.0	0.5	—
Nicrosilal iron (1st batch).							
Air (0.564 in. specimens) ..	9.4	9.5	9.5	9.5	1.5	1.5	1.5
Air (0.35 in. specimens) ..	10.8	11.7	—	11.2	1.5	2.5	—
450 ,, ,, ..	7.9	8.7	—	8.3	0.5	1.5	—
538 ,, ,, ..	7.7	7.7	—	7.7	1.5	1.5	—
Niresist iron.							
Air (0.564 in. specimens) ..	8.7	8.8	10.7	9.4	0.5	0.5	0.5
Air (0.35 in. specimens) ..	11.6	11.1	—	11.3	0.5	0.5	—
450 ,, ,, ..	9.8	10.7	—	10.2	0.5	0.5	—
538 ,, ,, ..	9.5	9.8	—	9.6	0.5	0.5	—

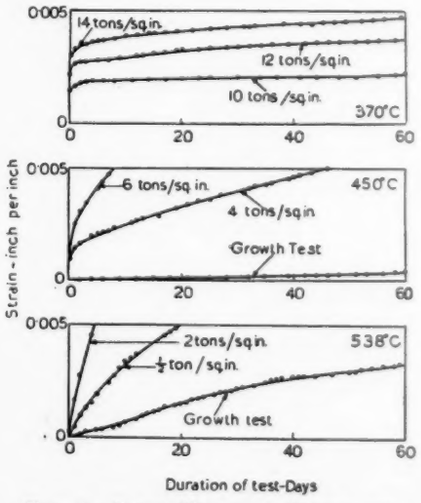

FIG. 3.—STRAIN/DURATION CURVES FOR NICKEL-CHROMIUM CAST IRON.

Creep and Growth Tests

The possible utility of cast irons from the point of view of the high-temperature steam-plant manufacturer depends not only on the ability of the irons to stand stress at high temperatures, but also on their resistance to growth or deformation in the absence of stress. Measurements of linear growth have, therefore, been made, using test-pieces of the same dimensions as those used for the creep tests, the test-pieces being free from any appreciable tensile stress. The measured growth could, therefore, be compared with the deformation due to both stress and growth in the creep tests. It cannot be stated whether or not the process causing linear growth is modified by applied stress; the deformations at different stresses in the creep tests do not, therefore, necessarily include a constant quantity attributable to growth, although, in general, the results obtained are not in disagreement with such an assumption.

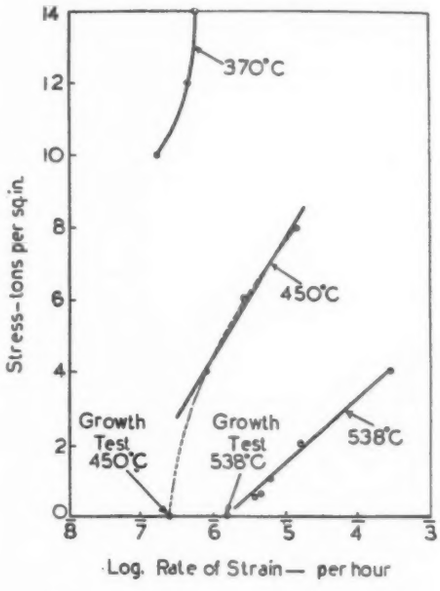

FIG. 4.—STRESS/LOG. RATE-OF-STRAIN CURVES FOR NICKEL-CHROMIUM CAST IRON.

The specimens used for the creep and growth tests were 0.3 in. in dia. and of 2 in. gauge length, and were machined from half-sections of the bars. Tests were made at 450 deg. C. (842 deg. Fah.) and 538 deg. C. (1,000 deg. Fah.), with additional creep tests at 370 deg. C. (700 deg. Fah.) in the case of the ordinary, nickel-chromium, and Silal irons. In all the tests the temperatures were maintained within ±2½ deg. C.

At an early stage in the experiments it was observed that different bars of both the ordinary and the Silal cast iron appeared to have somewhat different creep properties, and comparative creep tests were, therefore, made on four bars of each iron to determine the order of variation. The tests were carried out at 450 deg. C.

TABLE IV.—*Results of Comparative Creep Tests at 450 deg. C. on Different Bars of Ordinary and Silal Cast Irons.*

Bar no.	Stress applied. Tons per sq. in.	Rate of strain at 15 days. In. per in. per hr.	
		Individual values.	Mean value.
Ordinary cast iron.			
1	4	0.0000017_9	
2	4	0.0000035_4	0.0000026_5
3	4	0.0000020_8	
4	4	0.0000032_1	
1	6	0.0000075	0.0000096
3	6	0.0000117	
Silal cast iron.			
1	5	0.0000010_4	
3	5	0.0000008_2	0.0000016_7
4	5	0.0000031_3	
2	4	0.0000012_8	
3	4	0.0000005_4	0.0000011_9
4	4	0.0000017_9	

(842 deg. Fah.) only. The results of the comparative creep tests on different bars are given in Table IV.

It will be seen that there was considerable variation in the creep rate at 15 days of different bars of each iron. The variations encountered cannot be attributed to differences in the rates of growth of the bars at 450 deg. C., since the rate of growth was found to be of the order of only 1.2×10^{-7} in. per in. per hr. in the case of the ordinary cast iron and less than 5×10^{-8} in. per in. per hr. in the case of the Silal cast iron. Comparative creep tests were not made on different bars of the other irons; the subsequent creep tests, however, indicated that they were not free from variability.

The main experiments were undertaken in order to provide an idea of the magnitude of the creep and growth of each of the five irons at the test temperatures. Later it is explained how both the creep and the growth of the ordinary and the nickel-chromium irons may be considerably reduced by pretreatment.

A number of specimens were examined microscopically before and after test, with the object of noting any structural changes produced and of elucidating some effects observed during the tests. Longitudinal sections were cut from the 1¼ in. dia. cast bars in the condition as-received, and from the creep and growth test-pieces. In the condition as-received, therefore, it was usually possible to examine the structure from the outside of the bar to the centre. As, however, the creep and growth test-pieces were machined from half-sections of the bars, the examination after test was confined to material taken from about half-way between the outside and centre of the original 1¼ in. dia. bars. Except where otherwise stated, the etching reagent used was 4 per cent. nitric acid in alcohol.

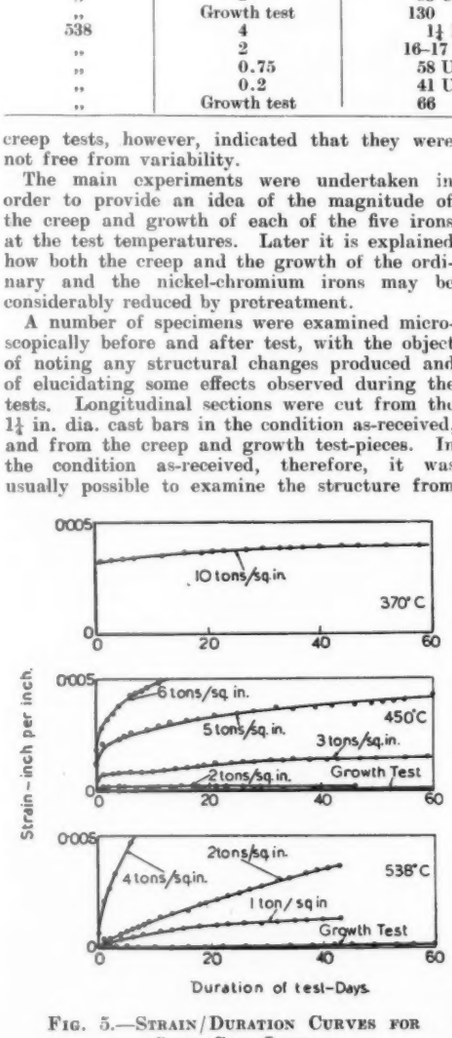

FIG. 5.—STRAIN/DURATION CURVES FOR SILAL CAST IRON.

The results of the creep and growth tests, and of the microscopical examination, are discussed below under separate headings for each iron.

Ordinary Cast Iron

Strain/duration curves for strains up to 0.005 in. per in. obtained in creep and growth tests on the ordinary cast iron are shown in Fig. 1. In this and subsequent figures showing creep curves the plotted strain includes both creep and such elastic deformation as may exist, and also growth.

Fig. 2 shows the relations between the stress and log. rate-of-strain at 40 days at the test temperatures. The rates of growth at 40 days are indicated by points along the axis of log. rate-of-strain. Growth tests were not made at 370 deg. C. (700 deg. Fah.). At 450 deg. C. (842 deg. Fah.) the rate of growth is small, but a very considerable increase occurs at 538 deg. C. (1,000 deg. Fah.). At both temperatures growth determines the minimum rate of deformation, and thereby defines the trend of the curves of Fig. 2 to zero stress.

TABLE V.—*Results of Creep and Growth Tests on Ordinary Cast Iron.*

Temperature of test. Deg. C.	Stress applied. Tons per sq. in.	Duration of test (B = broken, U = unbroken). Days.	Final strain at fracture or at end of test. Per cent. (on 2 in.).	Rate of strain, minimum or at 40 days. In. per in. per hr.
370	12	40 U	0.63_5	0.0000014_5
,,	10	55 U	0.49	0.0000008_9
,,	8	41 U	0.25	0.0000003_3
450	8	9 B	2.5	0.0000458
,,	6	89 B	3.25	0.0000075
,,	4	93 U	0.44	0.0000012_9
,,	2	83 U	0.12_5	0.0000002_5
,,	Growth test	130	0.02	0.0000001_2
538	4	1¼ B	3.0	—
,,	2	16–17 B	4.0	0.0000775
,,	0.75	58 U	3.0	0.0000091_7
,,	0.2	41 U	1.14	0.0000050
,,	Growth test	66	0.91	0.0000032_9

The numerical results of the creep and growth tests are given in Table V, which contains data concerning the time to fracture and elongation at fracture (final strain) of the most highly stressed specimens. There is an indication that the elongation at fracture increases somewhat with increase in the time required to produce fracture.

Measurements show that growth is continuous at 450 deg. C. and 538 deg. C., and has not ceased in 130 days and 66 days at the respective temperatures. The magnitude of the growth is such as to preclude the use of the iron (as-cast) at such temperatures if deformation of any kind has to be severely limited. It was considered probable that the growth could be considerably reduced by prior heat treatment; the tests described later, using the ordinary and the nickel-chromium irons, show that an improvement can be effected by heat treatment.

The structure of the cast iron was found on micro-examination to be uniform across the section. The structure showed that under a creep stress of 2 tons per sq. in. for 16-17 days at 538 deg. C. there was little evidence of cracking, but the pearlite had very largely broken down. The resulting graphite had been deposited on the existing flakes or as a very finely divided precipitate in the ferrite. From these and other similar results, it appeared that the structural changes occurring during the tests depend upon the time of exposure rather than upon the magnitude of the stress.

Specimens were examined after creep for 89 days and growth for 130 days at 450 deg. C., but no appreciable difference from the original condition was noted. Specimens tested at 370 deg. C. were, therefore, not examined.

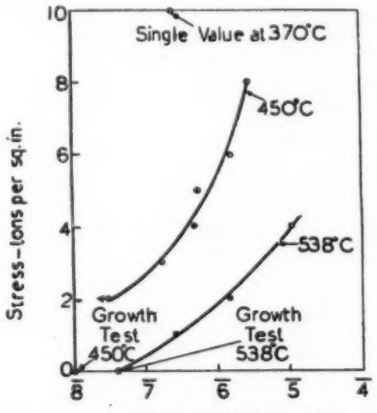

FIG. 6.—STRESS/LOG. RATE-OF-STRAIN CURVES FOR SILAL CAST IRON.

Nickel-Chromium Cast Iron

Strain/duration curves for the nickel-chromium irons are shown in Fig. 3, and the stress/log. rate-of-strain relations are given in Fig. 4. Table VI gives the numerical results of the tests.

The rate of growth at 450 deg. C. is somewhat greater for this iron than for the ordinary cast iron, with the result that the deformations of the two irons under stresses up to 2 or 3 tons per sq. in. are similar. The nickel-chromium iron is somewhat superior to the ordinary iron at 538 deg. C., but its rate of growth at both 450 deg. C. and 538 deg. C. is such as to exclude material in the as-cast condition from service at those temperatures. It is shown later that a considerable improvement of the nickel-chromium iron as regards resistance both to creep and to growth can be effected by heat treatment.

TABLE VI.—*Results of Creep and Growth Tests on Nickel-Chromium Cast Iron.*

Temperature of test. Deg. C.	Stress applied. Tons per sq. in.	Duration of test (B = broken, U = unbroken). Days.	Final strain at fracture or at end of test. Per cent. (on 2 in.).	Rate of strain, minimum or at 40 days. In. per in. per hr.
370	14	81 U	0.49	0.0000005_7
,,	12	84 U	0.41	0.0000004_5
,,	10	62 U	0.23	0.0000001_7
450	8	11–12 B	1.0	0.0000142
,,	6	81 U	0.87	0.0000027_1
,,	4	91 U	0.36_5	0.0000007_9
,,	Growth test	89	0.06	0.0000002_4
538	4	2 B	2.0	—
,,	2	77 U	3.92	0.0000158
,,	1	77 U	1.31	0.0000061_7
,,	0.625	69 U	1.04	0.0000045
,,	0.5	37 U	0.70	0.0000037_5
,,	Growth test	78	0.37	0.0000014_6

The results plotted in Fig. 4, of the creep tests at 370 deg. C., suggest that the iron will withstand a stress of a few tons per sq. in. without serious deformation.

The structure of this iron showed unusual fringes of graphite which were noticed close to and parallel to the main graphite flakes in certain sections examined. In the more generally

observed type of structure representing the actual structure after creep at 4 tons per sq. in. for two days at 538 deg. C., the graphite flakes were uniform and not too large, whilst the distribution of graphite and phosphide eutectic appeared to be regular throughout. As in the ordinary iron, the background was pearlitic. Further creep specimens which have been subjected to test at 538 deg. C. for more prolonged periods were not examined, as it was considered that any resulting changes in microstructure would be shown equally in the more prolonged growth tests. The microstructure observed in the growth specimen after 78 days at 538 deg. C. after light etching, shows the more usual type of graphite, and indicates that, although there has been a tendency for the cementite to spheroidise, only slight decomposition into graphite, etc., appears to have taken place. However, a number of transverse and longitudinal fissures, for the most part rectilinear, are to be seen in certain places, which correspond frequently with the appearance of "fringed" graphite. It was, therefore, thought at first that this "fringed" graphite was a sign of incipient oxidation and general break-up of the material. The fact that "fringed" graphite is sometimes found in this iron in the as-received condition appears, however, to contradict this suggestion and point to its formation as being due to a decomposition of the austenite during cooling after casting. It should be noted that this iron contains about 2 per cent. of silicon which has probably been added to counteract the effect of the chromium, which might otherwise cause the formation of an undue proportion of carbide.

TABLE VII.—*Results of Creep and Growth Tests on Silal Cast Iron.*

Temperature of test. Deg. C.	Stress applied. Tons per sq. in.	Duration of test (B = broken, U = unbroken). Days.	Final strain at fracture or at end of test. Per cent. (on 2 in.).	Rate of strain, minimum or at 40 days. In. per in. per hr.
370	14	8 B	0.5	—
,,	10	94 U	0.19_5	0.0000002_5
450	8	2 B	0.5	0.0000028_3
,,	6	42 B	0.5	0.0000015_8
,,	5	248 U	0.45	0.0000005_6
,,	4	309 B	0.5	0.0000005
,,	3	171 U	0.09_5	0.0000001_7
,,	2	46 U	0.00_3	$<0.0000000_3$
,,	Growth test	114	0.00_{35}	$<0.0000000_1$
538	4	33 B	1.25	0.0000104
,,	2	43 U	0.18	0.0000014_4
,,	1	43 U	0.06_3	0.0000002_5
,,	Growth test	62	0.00_{75}	$<0.0000000_4$

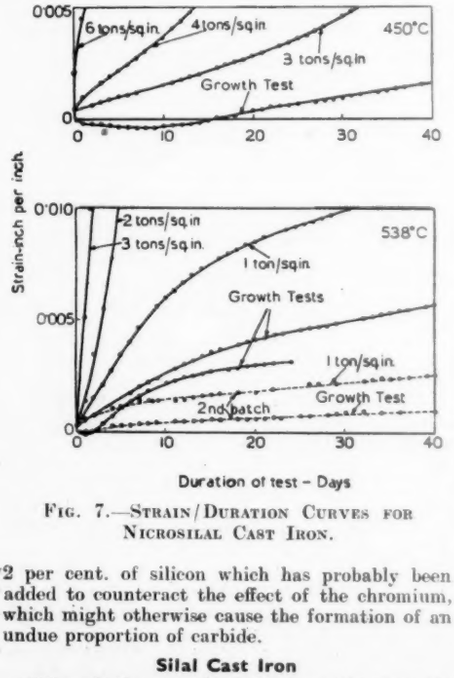

FIG. 7.—STRAIN/DURATION CURVES FOR NICROSILAL CAST IRON.

Silal Cast Iron

Although the growth of Silal cast iron at 450 deg. C. and 538 deg. C. was discernible, it was very small in amount and not accurately measurable. The deformations in the creep tests may, therefore, be taken to represent true creep strain, the microscopical evidence of structural change, as described later, being such as to indicate that growth was not likely to be appreciably influenced by the applied stress.

Fig. 5 shows the strain/duration curves obtained, and Fig. 6 the relations between the stress and the log. rate-of-strain. The numerical results of the tests are given in Table VII.

The Silal cast iron is definitely superior to the ordinary and nickel-chromium cast irons. The rate of strain at 370 deg. C. for a stress of 10 tons per sq. in. (see Fig. 6), and the further creep test results at 450 deg. C. and 538 deg. C. demonstrate the load-carrying possibilities of the iron. At 450 deg. C., for example, a stress of 4 tons per sq. in. produces a creep rate at 40 days of 5×10^{-7} in. per in. per hr., and the material supports this stress for 309 days before fracture ensues, but at 2 tons per sq. in. the creep rate is only about one-twentieth of that at 4 tons per sq. in.

The structure near the outside of the bars as-received is dendritic. The graphite is small and largely of the supercooled type, and there is no pearlite present. In the structure near the centre of the bar the graphite flakes are small, and the supercooled type of graphite is not so conspicuous. Thus the structure of the Silal bars is not as uniform as that of the two previous irons. The same structure at higher magnification shows the appearance of the phosphide eutectic. In certain places near the centre of the bar a trace of an unusual structure, possibly of a further constituent, is found within the ferrite grains. The structure in the ferrite is more clearly developed after prolonged treatment at 450 deg. C., after creep and growth tests for 43 days and 114 days respectively. There is a tendency for the constituent in the ferrite to break up after a time, and this is more noticeable in tests at 538 deg. C. Apart from the behaviour of the ferrite, there appears to be little general structural change during treatment at 450 deg. C. or at 538 deg. C.

Nicrosilal Cast Iron

The structure of the first batch of this iron was found to be somewhat variable. From a micro-examination it appeared that the composition is critical, in that very slight changes either in the composition or the conditions of casting may cause considerable differences in structure. Whatever the type of graphite, the iron consists mainly of austenite, which is only slightly etched after immersion in a 12 per cent. solution of nitric acid in alcohol for 1 min. A second light-etching constituent is also present in small amounts. This constituent has not been identified, but it appears likely to be related to the phosphorus content and takes up an interdendritic position.

Creep and growth tests were made at 450 deg. C. and 538 deg. C. on the first batch of Nicrosilal cast iron. The strain/duration curves obtained are shown in Fig. 7, and the corresponding stress/log. rate-of-strain curves in Fig. 8. Table VIII contains the numerical results of the tests. At 450 deg. C. the sample of Nicrosilal cast iron examined is inferior to the ordinary cast iron, and at 538 deg. C. is very similar to the nickel-chromium cast iron. Its growth is very much greater than that of the Silal cast iron.

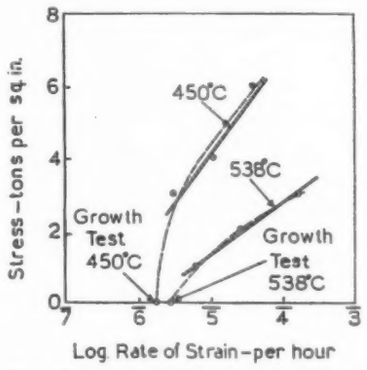

FIG. 8.—STRESS/LOG. RATE-OF-STRAIN CURVES FOR NICROSILAL CAST IRON.

At 538 deg. C. the strain/duration curves of the Nicrosilal iron have a somewhat unusual character, mainly demonstrated in Fig. 7 by the growth curve and the curve for a stress of 1 ton per sq. in. The curves show that a fairly steady rate of strain occurs for several days, followed by a rapidly decreasing rate and then by comparatively little change in rate. It was found that the Brinell hardness of the creep and growth specimens varied from a value of about 135 before the test to about 430 after 40 days at 538 deg. C. A growth specimen maintained at 450 deg. C. for 44 days also showed considerable hardening, which varied from one end of the specimen to the other, thus confirming that the original bar was not uniform along the length. These unusual characteristics suggested that changes were taking place in the iron during test, and these have been studied microscopically. The microstructure of a specimen after creep test at 3 tons per sq. in. for 18 days at 538 deg. C. showed that the austenite had very largely broken down to a dark-etching sorbite, and, as would be expected, the material was no longer non-magnetic. The same type of breakdown occurred at 450 deg. C., but the process was considerably slower than at 538 deg. C.

The structure of the creep specimen suggests that the original austenite grains were cored,

TABLE VIII.—*Results of Creep and Growth Tests on Nicrosilal Cast Iron* (*1st Batch*).

Temperature of test. Deg. C.	Stress applied. Tons per sq. in.	Duration of test (B = broken, U = unbroken). Days.	Final strain at fracture or at end of test. Per cent. (on 2 in.).	Rate of strain, minimum or at 40 days. In. per in. per hr.
450	6	38 B	8.0	0.0000417
,,	4	20 U	0.78	0.0000117
,,	3	40 U	0.69	0.0000031_2
,,	Growth test	44	0.16_3	0.0000018_2
538	3	18 B	11.0	0.0001710
,,	2	41 U	4.42	0.0000271
,,	1	40 U	1.07	0.0000062_5
,,	Growth test	43	0.58	0.0000028_1

and it was thought that this lack of uniformity in composition might be related to the comparatively rapid breakdown. In order to test this, a number of samples were annealed for 3½ hrs. at 1,080 deg. C. This treatment was found to effect considerable diffusion of the interdendritic constituent, and gave greater uniformity to the austenite. These specimens were then maintained at 538 deg. C., together with specimens from the same bar which were not annealed at 1,080 deg. C. Specimens were examined after three days, six days and 24 days. It is found that in the unannealed samples, austenite breakdown occurs in areas which have a direct relationship to the original dendritic structure, whereas in the annealed samples breakdown occurs rather less rapidly, starting from comparatively few centres and spreading gradually through the material. These changes are also shown by the following Brinell hardness values:—

Time held at 538 deg. C. Days.	Brinell hardness no. As-received.	Annealed.
0	135	135
3	265	157
6	333	260
24	431	430

The hardness numbers are the mean of several, and were obtained with a 1-mm. ball and load of 30 kg. Owing to variation across the section, the values given above must be taken as representing the general trend of hardness changes and not as absolute values.

The opinion was expressed that, although the particular iron investigated was suitable for severe service conditions at temperatures above about 800 deg. C., the composition was probably critical as regards stability of structure at 538 deg. C. A fresh batch of slightly different composition was, therefore, obtained (see Table I), and tested for creep and growth at 538 deg. C. The results obtained are shown by the dotted curves in Fig. 7, which disclose that the second batch of Nicrosilal iron was somewhat superior to the first. However, hardening was still found to take place during the creep test at 538 deg. C., the Brinell hardness being 160 before test and 320 after test. In addition, microscopical examination revealed that the same structural breakdown occurred, though less rapidly than in the case of the first batch of the iron.

Niresist Cast Iron

The strain/duration curves obtained in creep and growth tests at 450 deg. C. and 538 deg. C. on the Niresist cast iron are shown in Fig. 9, and the corresponding stress/log. rate-of-strain curves are shown in Fig. 10. The numerical results of the tests are given in Table IX.

The growth of this iron at 450 deg. C. was found to exceed that at 538 deg. C., and for that reason the curve in Fig. 10 for the tests at 450 deg. C. crosses that for the tests at 538 deg. C. The rate of strain under a stress of about 3 tons per sq. in. is the same at both temperatures, but at lower stresses the rate of strain would be greater at 450 deg. C. than at 538 deg. C. The Niresist cast iron has the best resistance to creep and growth at 538 deg. C. of the irons tested, but at 450 deg. C. the Silal iron, by virtue of its very low growth, is superior to the Niresist iron.

The microstructure of the Niresist cast iron, like Nicrosilal, is austenitic. The polished specimen, however, is very much more easily etched than that of Nicrosilal, and the austenite contains quite a large proportion of a light-etching constituent which appears as a eutectic.

A creep specimen which had been stressed at 6 tons per sq. in. for six days at 538 deg. C. exhibited a structure almost identical with that of the original material, and even after 41 days in the growth test the only obvious change was that due to the precipitation of additional graphite around the eutectic areas, as referred to below. In view of the fact that Niresist has less resistance to creep and growth at 450 deg. C. than at 538 deg. C. it was thought that the austenite might be less stable at 450 deg. C. Microscopic examination of a growth specimen after 56 days at 450 deg. C., however, showed that the austenite had not decomposed. In addition, the growth specimens were found to remain non-magnetic, and it is clear, therefore, that at 538 deg. C. and at 450 deg. C. the stability of the austenite in Niresist is much greater than that in Nicrosilal.

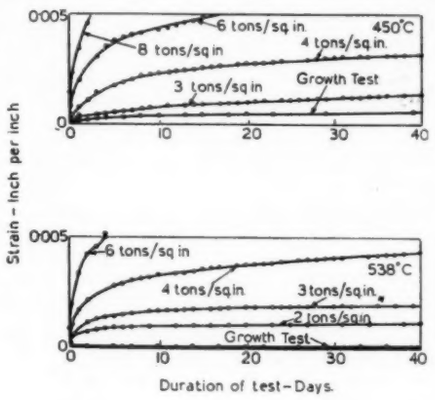

FIG. 9.—STRAIN/DURATION CURVES FOR NIRESIST CAST IRON.

TABLE IX.—*Results of Creep and Growth Tests on Niresist Cast Iron.*

Temperature of test. Deg. C.	Stress applied. Tons per sq. in.	Duration of test (B = broken, U = unbroken). Days.	Final strain at fracture or at end of test. Per cent. (on 2 in.).	Rate of strain, minimum or at 40 days. In. per in. per hr.
450	8	42 U	1.04	0.0000018_7
,,	6	40 U	0.57	0.0000009_2
,,	4	40 U	0.32	0.0000004_8
,,	3	44 U	0.13	0.0000003_3
,,	Growth test	56	0.06	0.0000002_1
538	6	6 B	1.5	0.0000095_8
,,	4	42 U	0.44	0.0000010_4
,,	3	40 U	0.19	0.0000002_1
,,	3 (repeat)	40 U	0.32	0.0000005_2
,,	2	40 U	0.11	0.0000001
,,	Growth test	41	0.01	0.0000000_5

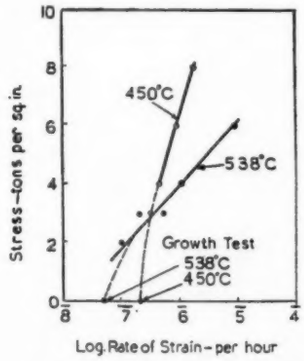

FIG. 10.—STRESS/LOG. RATE-OF-STRAIN CURVES FOR NIRESIST CAST IRON.

Considerable graphitisation occurred during tests at 538 deg. C. and 450 deg. C.; the effect upon the microstructure was noted. In order to obtain quantitative information, millings were taken from the growth specimens, their carbon contents being compared below with those for the iron in the condition as cast:—

	As cast.	After growth for— 56 days at 450 deg. C.	41 days at 538 deg. C.
T.C., per cent.	2.44	2.45	2.36
Gr., per cent...	1.70	2.14	2.20
C.C., per cent.	0.74	0.31	0.16

Within the limits of accuracy of these determinations, it may be concluded that graphitisation has proceeded further in 41 days at 538 deg. C. than in 56 days at 450 deg. C. Although it cannot be assumed that the figures for combined carbon represent equilibrium values for the particular temperatures, there is evidence that the stable condition is reached more rapidly at 538 deg. C. than at 450 deg. C., and it is possible that this may have some bearing on the unusual relationship of both the growth and the creep properties at the two temperatures.

(To be concluded.)

British Acetylene Association

The thirty-fifth annual general meeting of the British Acetylene Association was held last week at the Mayfair Hotel, London, when **Dr. J. D. Pollock was elected President for the ensuing year. Subsequently he presided at a luncheon at which a large number of distinguished guests were present. Mr. A. B. Harrower, one of the representatives on the Permanent International Committee, referred to the forthcoming International Congress of Acetylene, Oxy-Acetylene Welding and Allied Industries to be held in London, June 8-13, and urged the wholehearted support of all who are interested in those industries.**

Dr. J. D. Pollock (President), referring to the objects of the Association, remarked that it was formed to promote the advancement of the use of acetylene and to facilitate the interchange of information amongst its members and others interested. In addition, its purpose was to confer on behalf of the industry with Government and other authorities with a view to improving the conditions of safety and, generally, extending the applications of acetylene. The conditions upon which the Association was formed remained the same. But the applications had changed materially, and instead of being used solely as an illuminant, acetylene was now mainly a fuel gas used in conjunction with oxygen for heating, welding and metal-cutting operations. **From this many allied processes had developed. The use of acetylene would still further increase as structural designs were adapted to welding** rather than riveting.

Catalogue Received

Dust Removal. Davidson & Company, Limited, Sirocco Engineering Works, Belfast, in publication number S.F. 213, deal with apparatus they have designed for combating silicosis trouble in the pottery industry. Owing to the close resemblance of this to the vitreous enamelling trades the pamphlet is of definite interest to foundries carrying out the latter process.

Grey Iron Under the Microscope*

By F. A. Wooley.

Readers of the technical journals published over the last few years have become familiar with a variety of microstructures, and perhaps, therefore, a few notes upon the more common constituents met with in grey iron will, if only by clarifying the position, merit attention. Research work on heat-treatment, superheating, alloying and virtually all the advances of grey-iron metallurgy which have characterised the post-war years have been illustrated by this medium.

Micro-examination can be carried out at precisely the position desired, thus permitting the investigation of localised parts. Estimation of the quantity of pearlite, and therefore of the combined-carbon content, can within certain limitations be made more quickly than by routine analysis, and quite as accurately. Estimation of phosphorus and to lesser degree of sulphur and graphite contents can be easily approximated. Besides the quantity of these constituents the more vital function of the microscope is to reveal their mode of distribution. For example, instances of irons having similar composition, but possessing widely differing physical strengths, have been repeatedly published, and the principle of securing requisite properties through structural arrangement, as distinct from chemical composition, is behind most of the grey-iron specifications.

Structurally, grey iron can be conveniently divided into two portions—the matrix, generally of eutectoid nature, but frequently containing more or less free ferrite or alternatively traces of free carbide; and the graphite particles, phosphide eutectic and manganese sulphide which occur as inclusions.

Eutectoid Cast Iron

Whereas eutectoid steel contains some 0.85 to 0.90 per cent. of combined carbon, it seems probable that with cast iron the eutectoid ratio is somewhat lower, owing to the influence of dissolved impurities. In the writer's experience, free ferrite can seldom be seen in iron containing more than 0.70 per cent. combined carbon, while free cementite can frequently be detected in samples analysing 0.85 to 0.90 per cent. of combined carbon. Incidentally, the presence of carbide-forming elements, such as chromium and manganese, in quantity may result in the persistence of particles of carbide in a matrix in which free ferrite can sometimes be detected; an apparent contradiction such as cast iron quite frequently supplies. Apart from the quantity of eutectoid present, its condition exerts considerable influence on the general properties. Thus, with a slowly-cooled sample, the pearlite will show the characteristic laminated formation, but if, as is common nowadays in modern high-speed casting units, the casting is knocked out shortly after pouring, is stripped and allowed to cool from red-heat in air, then the laminated formation will be suppressed in favour of a structureless or sorbitic structure. Thirdly, if sufficient alloying elements, such as nickel or manganese, are present, or the sample is quenched in water, then martensite or troostite will be found. All are direct analogies to similar conditions on steel.

The matrix is the strength-supplying constituent, and since the tensile strength of pearlitic eutectoid steel is in the neighbourhood of 50 tons per sq. in. and increases with transitions to the sorbitic and martensitic conditions, the fall to the more usual 15 to 20 tons per sq. in. of present-day irons must be attributed to the graphite and other impurities present. The problem of producing high-test iron viewed from a structural point of view resolves itself into a question of obtaining the strongest possible matrix with the minimum of discontinuities.

There is one divergence from the parallel with steel that the writer should mention, namely, that in quenched samples, although hardness is at its maximum, the tensile strength falls off to below the "as-cast" level, and only on moderate tempering does it reach, and often greatly exceed, that figure. Of the other constituents present, the graphite is easily the most important, and to the presence of this element the material owes many of its most distinctive properties.

Factors Influencing Graphite Condition

The graphite structure of a present-day grey iron comfortably passing the B.S.I. 321/28 Specification would in a $\frac{3}{8}$-in. dia. bar show fairly short, flakey particles, with a tendency to occur grouped into rosette formations, becoming progressively coarser and more flakey with increasing section. That is the normal structure. The main effects of the eutectic graphite or supercooled structures developed by Piwowarsky in the work leading up to the once very popular nucleus theory may be summarised as follow: By breaking up the continuity of the strong pearlite, graphite contributes largely to the almost complete loss of ductility; to the great fall in tensile strength; but, according to recent work, does not harm the fatigue resistance to anything like the same degree.

As Prof. Turner has shown, the separation of graphite during the solidification causes expansions which so largely minimise shrinkage difficulties that, despite its high melting point, cast iron is one of the easiest metals to cast. The breaking-up effect on the hard pearlite matrix facilitates machining operations, and the lubricating properties render the material exceptionally suitable for service where wear resistance is necessary.

The ideal condition between the eutectic-graphite formation and the coarse, flakey variety will depend upon the use for which the iron is intended. For strength and wear resistance the short, thick, uniformly-distributed particles are probably the best, allowing as they do a maximum of graphite to produce the minimum of discontinuity. For machinability the maximum breaking-up effect is desired, since the eutectic graphite tends to occur at the grain boundaries, and, moreover, is usually associated with free ferrite.

Finally, with regard to sulphur and phosphorus, the former has always been regarded as an impurity, but not when adequately combined with manganese as manganese sulphide, a particularly harmful one. The formula—worked out by Norbury—of $1.7 \times S$ per cent + 0.3 per cent. = desirable manganese content has received considerable publicity, and finds repeated confirmation in current practice.

Under the microscope, the characteristic dove-grey particles can be easily recognised, and unless badly segregated are not of great importance. Phosphorus is also being treated more as an impurity and less as an essential constituent. The occurrence of the binary phosphide eutectic, one part of phosphorus producing ten times its bulk of steadite, although promoting fluidity and sharpness of outline of the casting, leads to difficulties from internal porosity and sinks, and the trend, especially in repetition foundries, is towards the use of the lower-phosphorus irons.

* An entry in the Short Paper Competition held by the Birmingham Branch recently.

At an extraordinary general meeting of British Reverberatory Furnaces, Limited, held at 88, Kingsway, London, W.C.2, on April 28, a resolution was passed "that the company be wound up voluntarily by means of a members' voluntary winding-up." Mr. A. W. A. Chivers and Mr. T. H. Underhill, 88, Kingsway, London, W.C.2, were appointed joint liquidators.

Hints for Making Monel Metal Welds

When cast iron is welded with a steel or iron electrode the fusion point is extremely hard and non-machinable, and the surface can only be finished by grinding. For this reason Monel metal electrodes were introduced and their use is now being extended, experience having shown that, with proper welding apparatus, they give a surface capable of being machined as readily as the parent metal.

The Monel metal rods supplied for the metallic arc welding of cast iron are coated with a special flux, which protects the weld metal from oxidation and fluxes off any oxides which may be formed. Bare Monel metal wire is available for oxy-acetylene welding and refined powdered borax should be used as a flux. With gas welding it is necessary to preheat the casting. Where possible electric welding is recommended.

Monel metal flows very differently from any other welding metal, consequently an operator must accustom himself to its use and not expect to obtain perfect results with the first attempt. The metal cannot be deposited overhead satisfactorily, and as a general rule the work should be flat, although it can be deposited vertically if judgment and caution are exercised.

The Monel metal should always be deposited on a cold section of the casting, and a bead not longer than two inches laid at one time. Immediately upon breaking the arc, this bead should be carefully peened with a light ball peen hammer. This produces a forged effect in the welded metal and relieves it of the strains due to cooling.

When using Monel metal rod to weld a casting in which there is pressure or a vacuum, after the Vee or opening has been padded with two layers of metal, all having been peened as above mentioned, the entire weld should be carefully and thoroughly caulked either by hand or with a pneumatic tool. In addition to the peening of every two inch bead, caulking should be continued after every second layer is completed, and when the opening or Vee is entirely filled in with Monel metal, the whole mass should again be caulked and also gone over with a roughing tool.

Particular care should be taken to deposit each and every two inch bead on cold metal, so it is therefore necessary either to keep moving from one part of the casting to another, or to cease welding operations until the metal has thoroughly cooled down. Welding cast iron must necessarily proceed slowly and where the above suggestions have been conscientiously adhered to by the operator, satisfactory results should be obtained.

Flux coated Monel metal rods for welding cast iron may be used with any type of electric welding machine, provided a temperature equivalent to the current recommended is maintained. Current at 175 amperes and a short arc are recommended for using Monel metal, 0.148 in. ($\frac{5}{32}$ in.) diameter; 100 to 130 amperes for 0.120 in. ($\frac{1}{8}$ in.) diameter, and 80 to 100 amperes for 0.093 in. ($\frac{3}{32}$ in.) diameter.

It is essential that the welding machine used produces the suggested amperages constantly. It may be necessary with some welding equipment to set the panel switches for a higher amperage than given in order to ensure an average of those recommended.

Among recent contracts received by Head, Wrightson & Company, Limited, of Thornaby-on-Tees, is an order for a pair of dock gates for Falmouth. They are for a dry dock having an opening of 75 ft., and each gate is 43 ft. long, with a height of 36 ft. from sill level to cope level. The contract includes the supply of all electrical operating machinery. There will be approximately 200 tons of steelwork.

A Discussion on Die-Castings

In our issue of April 23 we printed a Paper by Mr. N. D. G. Robertson read before the annual joint meeting of the London Branches of the Institute of British Foundrymen and the Institute of Metals. It gave rise to a very interesting discussion which was opened by MR. V. DELPORT (Vice-President of the London Branch of the I.B.F.) who deputised for Mr. F. O. Blackwell (President of the London Branch). Mr. Delport expressed the appreciation of the members to the London Section of the Institute of Metals for having afforded the opportunity for the joint meeting, and for the hospitality afforded the visitors.

With regard to pressure die casting in contradistinction to gravity die casting, he said that it was usually practised in large quantity production, and it was limited to a certain number of alloys and to relatively small pieces. The cost of the necessary installation was high and the dies were expensive. On the other hand, the process involved less labour than did normal methods of casting, and less space was required. Considerable work on pressure die casting had been done in America, France and Czechoslovakia.

Anodising

MR. A. H. MUNDEY (Past-Chairman, London Section, Institute of Metals) expressed special interest in Mr. Robertson's remarks concerning the necessity for co-operation between designers and potential users of die-castings, and the makers of die-castings and their die designers. He commented upon the efforts of all foundrymen, for the elimination of unsoundness in all castings and stated that a critical examination of castings produced under high pressure had shown that a very large measure of success had attended these efforts. The high degree of skill displayed by both designers and makers of dies was also mentioned. Emphasising that the production of pressure die castings was really skilled and difficult work, he said one was impressed when one saw the men in pressure die casting shops working with the precision of a gun team, and producing rather intricate castings. He had seen die castings being made to a weight of over 50 lbs.

With regard to the anodising of aluminium alloys, Mr. Mundey said that it was difficult to anodise some of them, particularly the aluminium-silicon alloys.

MR. A. F. GIBBS (Past-President, London Branch, I.B.F.) said that foundrymen in general were not unduly perturbed by the new competitors; indeed, they welcomed those competitors, more particularly after having heard Mr. Robertson's lecture. Mr. Robertson had been very candid and one felt that he would make a bad commercial traveller because he had not said that everything was satisfactory.

In asking whether Mr. Robertson preferred electricity to gas or some other medium for melting the metal for die casting, Mr. Gibbs said that he was also interested in pressure die casting in connection with piston-packing metal, using a gas-fired furnace, and he had experienced some trouble due to the gas entering the metal. He had been particularly interested in the idea of using a vacuum for extracting the air from the dies, and he was wondering whether it would pull the gas out of the metal as well. He also asked what iron Mr. Robertson would use for his metal pots, and whether one could use a sort of whitewash or a graphite mixture to prevent the gas entering. He personally had tried such things but was still troubled with gas holes in the metal. It had been stated in the lecture that some special kind of steel was required with certain articles, but Mr. Robertson had not indicated what kind of steel was required.

Discussing the question of pressure die casting *versus* gravity die casting, he recalled that some time ago he had visited a works dealing with aluminium and had asked to see the pressure die casting apparatus. The manager of those works had expressed himself as being in favour of gravity die casting every time; he might, however, have changed his mind since then.

The Toy Trade

MR. G. L. BAILEY, commenting upon the colour due to the anodising of aluminium castings, said he presumed that Mr. Robertson's remarks on that matter had applied only to the silicon alloys. The silicon alloy was one of the best of the aluminium alloys for die casting, and one of the most widely used. It offered difficulties in connection with anodising, however, in that the anodic film was naturally coloured, apart from any dyeing treatment that one might wish to apply afterwards. It had seemed that Mr. Robertson had suggested that all aluminium alloys which could be die cast gave a purple anodised film, but he did not think Mr. Robertson had really meant to say that.

In a reference to Mr. Robertson's candour concerning the difficulties of securing internal soundness in pressure die castings, Mr. Bailey disagreed with the suggestion that because Mr. Robertson had been so candid he would make a bad salesman. One felt that the days had passed when a salesman could say that everything he had to offer was perfect; the man who was prepared to admit a difficulty would gain the customer's confidence.

Commenting upon a specimen of a cast-iron die casting which Mr. Robertson had exhibited, he asked whether it was made by the Holley process, and if not, whether he was proposing to give more details of the exact method of manufacture.

In asking for more information on the various alloys used for die casting, and particularly for slush casting, Mr. Bailey referred to the casting of lead toys as an aspect of slush casting in which he was very interested. The toys were slush cast in a particularly brittle material, and when a toy had been dropped and one tried to straighten it, it would break. He presumed that the lead-antimony alloy normally used for that purpose had been adopted because it gave a very nice impression of the mould; but it did seem a pity that with all our metallurgical knowledge, we could not produce a better lead-alloy slush casting in a material sufficiently ductile to enable it to be bent straight again after it had been distorted.

Centrifugal Castings

DR. A. B. EVEREST (Vice-President, London Branch, I.B.F.) said that he was speaking primarily as a member of the Institute of British Foundrymen and he was therefore interested especially in die casting as applied to the ferrous alloys. This he understood was developing, and he mentioned that recently he had seen a machine for die-casting pistons and other simple parts in cast iron and he had gathered that the process was now a commercial possibility.

With regard to the question of soundness of castings he queried the suggestion made by Mr. Mundey that all castings were unsound and he suggested that possibly centrifugal castings were an exception.

Referring to centrifugal castings he suggested that they might legitimately be included under the title of the Paper, and in this connection it was of interest to note that work was now being undertaken in Sheffield with a view to making quite large centrifugal castings even in stainless steel, a material of very high melting point. He had rather gathered from the lecturer that the progress of die casting was dependent upon the progress in the development of material for moulds and he thought therefore that it would be of interest to hear more about this aspect of the problem. Obviously in the production of cast iron and also of steels as die or centrifugal castings the moulds had a very great deal to do with the results. In the casting of high melting-point metals the life of the moulds would necessarily be short and he asked if he was right in assuming that high melting-point steels were necessary for the dies or moulds and also how the problem was affected by the question of mould dressings.

MR. H. W. G. HIGNETT, discussing porosity in castings, recalled his only visit to a die casting foundry; the owners had also a large sand foundry, and he had learned that there was a very secret process for de-gassing aluminium alloys. He had learned as much as the people there would tell him about it—which was not very much—and to get rid of him quickly they had taken him through the die casting shop. There he had noticed a preliminary process for the production of a certain casting; the operator was stirring the metal with a stick, the purpose being to put gas into the metal so that it would not crack.

The reference to gravity *versus* pressure die casting brought to mind a recent Paper by Prof. Hanson and Dr. Slater; he suggested that perhaps Dr. Slater would contribute some remarks on the application of pressure to produce die castings which to all intents and purposes were sound because of the forced solution of the gases in the metal.

Zinc Base Castings

MR. J. CARTLAND, having congratulated the author upon giving the meeting a good perspective of the die casting position, emphasised the author's insistence upon the importance of designing for die casting, because so many things had been designed without reference to die casting, but had subsequently to be considered or made by this process. It was necessary to co-operate on design almost from the time of the original conception in the mind of the inventor or manufacturer. He asked whether the unsatisfactory results obtained with zinc base castings was due to the high surface tension of the zinc or to other factors. He also asked for Mr. Robertson's views on the commercial prospects of cast iron die casting.

The reference to homogeneity and porosity in the early part of the Paper had rather confused him. It had been stated that by the use of a vacuum, completely homogeneous castings could be produced; but from a subsequent reference to porosity, it would seem that Mr. Robertson had meant that the castings were free from porosity rather than completely homogeneous.

After a request for further information with regard to die material, Mr. Cartland expressed the view that the case for die castings was beyond question. Anyone who had visited a sand foundry and had noted the care exercised by the foundrymen to produce beautifully finished moulds, felt that it was a shame that each mould could be used only once. That was the primary idea behind all die castings.

He expressed surprise that yellow-metal pressure-die castings had not developed a great deal further than in fact they had. Those who had seen zinc-base die-castings noted their fine finish, which eliminated all machining; but the zinc-base metal was unsuitable for many purposes and lacked ductility. Aluminium-bronze had excellent properties, but in the gravity casting of aluminium-bronze there was nothing like the precision and finish attained with the zinc-base die-castings. Mr. Robertson had said that it was now possible to produce a pressure-cast brass having superior properties and something approaching the same limits of finish and accuracy. One would have thought that everybody would have clamoured for such castings; but they had not developed as

expected. He had asked whether that lack of development was due solely to the shorter life of the moulds, which naturally added to the cost of production.

Magnesium Alloys

MR. A. J. MURPHY, referring to magnesium alloys, said that the developments in die-casting Elektron, coupled with recent progress in the heat treatment of Elektron alloys, offered considerable prospects for extending the field for such die-castings in important engineering applications.

He wished to support what had been said about co-operation between designer and die-caster, instancing examples where drilling holes in lugs might be a better economic proposition than producing them by coring in the die.

Mr. Murphy saw no reason why we should follow the American practice of confining the term "die casting" to pressure die castings. Any article cast in a die, whether by gravity or under pressure, was a die casting.

MR. C. M. AUTY drew attention to some experiments, described in the Journal of the Institute of Metals, made about twenty years ago in the casting of an aluminium-bronze alloy containing 2 per cent. of iron. Mr. Auty asked whether that alloy was still being used and whether it had any special advantages over a plain aluminium-bronze or a manganese-aluminium-bronze.

He pointed out that in the discussion of the subject, the late Dr. Rosenhain had stated very forcibly that a gravity die casting was not a die casting and that a die casting was a pressure casting.

AUTHOR'S REPLY

MR. ROBERTSON, replying to Mr. Mundey, said that the aluminium-silicon alloys were easily treated anodically, but they did not take colour well. An alloy containing a small amount of magnesium and a very small amount of silicon would take anodic treatment satisfactorily, and would take the dye fairly well.

With regard to the construction of dies for gravity and pressure die casting, he said that there was very much more intricate work in the manufacture of the pressure die than in that of the gravity die. On the other hand, one could not use an ordinary gravity die and put the runner or riser just where one wished and expect to make a light casting. That was why he had said that the technique of the design of the die called for very much more attention than in normal pressure work.

Town's Gas Preferred

He considered that gas was possibly the best means of melting the metal. He would not suggest that electricity would not give the same degree of control as would gas, but in connection with die casting the use of electricity for melting was too expensive. Oil had been used, but he preferred gas. The use of coke was entirely out of the question; it resulted in a dirty shop and there were possibilities of getting coke and ash into the metal, whilst in addition, one had no control over it as a heating element. It might be satisfactory for melting up or alloying, but not for general purposes in die casting. His works used carborundum or graphite pots. A number of firms still used iron pots, but iron was really an enemy.

The cast-iron die casting he had exhibited was not produced by the Holley process but by a method evolved at his own works, purely from an experimental point of view, and an ordinary normal die was used. His works used a special dressing and had experimented with a special method in teeming the iron and making the iron froth very freely without any oxide formation.

Tin Toys and Die Steels

Mr. Robertson confessed that he did not like slush casting. He suggested that for the production of "tin soldiers," Mr. Bailey might get better results by using aluminium containing a small percentage of magnesium. He would like to be able to give information about die steels but these were one of the biggest troubles experienced. They had their own ideas about it at the author's works, but rather guarded them. He wondered whether Mr. Mundey had ever considered the use of steels which did not require heat treatment.

The dressings for dies were very important indeed, whether in gravity or pressure work, and had a very distinct bearing on the results obtained. A great number of pressure die castings was produced with virtually no dressings at all, but he believed that if more time was spent on considering dressings, more satisfactory castings would be produced and the lives of the dies would be lengthened.

Cast-Iron Die Casting

Replying to Mr. Cartland, he said he certainly thought that cast-iron die casting had commercial prospects; he could foresee no real difficulties when once the problems of getting the metal clean, and the type of dressing to be used on the mould had been overcome. The annealing afterwards was quite a simple matter. In his view, the iron to be used should have a fairly high silicon content, and if the metal were treated properly—one might call it "modified"—he believed it could be quite a commercial proposition.

As to the suggestion that the lack of development of yellow-metal pressure castings might be due to the short life of the moulds, he said that very great advances had been made in the type of steel used in the manufacture of dies for brass. In his opinion, the greatest difficulty in both the pressure and the gravity die casting of brass was the oxide formation. He believed that those who had made a success of brass die-casting—and there were not many, for numbers had tried and failed—had achieved their success not entirely by reason of design, but partly by reason of their methods. Unless one knew how to modify the brass one would never produce successful brass die casting by gravity. Modifications also produced better pressure die castings.

Replying to Mr. Auty, he said that aluminium-bronze and brass containing 2 per cent. or more of iron were being cast. The P.M.G. products, which were brass or bronze alloys containing quite a high content of iron, were being die-cast successfully and were in considerable use. The tensile strength of aluminium-bronze was increased very considerably when iron was incorporated—a tensile figure of 40 tons could be obtained, whilst the tensile strength of brass alloys could be raised to about 30 tons by the inclusion of iron.

THE CHAIRMAN (Dr. C. J. Smithells) pointed out that electric melting was employed in one of the most successful die-casting process, *i.e.*, type metal; he believed that that could legitimately be called a die casting process. It seemed extraordinary, commented the Chairman, that although Mr. Robertson's company experienced troubles with regard to the steels for making dies, they maintained secrecy in that connection. Surely, if this problem gave rise to such great trouble, the best thing to do was to get together and try to solve it!

Vote of Thanks

MR. V. DELPORT, proposing a vote of thanks to Mr. Robertson for his Paper, took the opportunity also to comment on the fact that the soundness of pressure die castings was not so good as that of gravity die castings. Inasmuch as the metal for pressure die casting was used in the pasty state, he wondered whether that fact was the cause of the lesser degree of soundness in those castings.

Referring to the displacement of labour by mass production, he said the answer to that problem was that in course of time, in view of the fact that articles could be made in large quantities by machinery, they became cheaper, so that the market was extended. The problem to be solved, however, was that of the lag between the time when labour was displaced and the time when more labour was required to meet the extended market.

The vote of thanks was seconded by MR. HIGNETT, and was heartily accorded.

Aluminium Alloy Castings

PROVISIONAL SPECIFICATION

The Air Ministry has issued material specification D.T.D. 287, relating to "Aluminium Alloy Sand or Die Casting (not suitable for pistons)," covering materials generally known as "Ceralumin B" and N.A.111 alloy. We append some of the principal clauses.

Quality of Material.—(*a*) The aluminium used for making this alloy shall be in accordance with the latest issue of British Standard Specification No. L.31. (*b*) The copper used for making this alloy shall be of a standard of purity equal to that of electrolytic copper. (*c*) No scrap shall be used other than that derived from the maker's own manufacture.

Chemical Composition.—(*a*) The chemical composition of the castings shall be:—Copper, 1.0 to 2.0 per cent.; nickel, 1.0 to 1.75 per cent.; silicon, 0.75 to 2.5 per cent.; magnesium, 0.05 to 0.2 per cent.; iron, 0.25 to 1.3 per cent.; cerium (if present), 0.05 to 0.3 per cent.; chromium (if present), 0.05 to 0.3 per cent.; aluminium the remainder.

Heat-Treatment.—(*a*) Unless otherwise specified in the contract, the castings shall be delivered in the heat-treated condition. (*b*) The castings and test samples shall be heated together to a temperature of 150 deg. to 175 deg. C. for 8 to 24 hrs. and quenched in oil or water or cooled in air.

Provision and Preparation of Test Samples.—(*a*) At least one test sample shall be cast to represent each large casting. When castings are made from more than one charge and the charges are not mixed prior to casting, a test sample shall be cast from each charge. When small castings are made by taking metal from a larger charge, one test sample shall be cast from every 100 lbs. of metal poured. (*b*) The metal for the test samples shall be taken directly from the same crucible or ladle of metal from which the casting or castings will be poured. The metal so taken shall not be subjected to any treatment other than cooling down to the appropriate pouring temperature. (*c*) The test samples shall be cast in dry-sand moulds of the dimensions laid down in the specification. The mould shall be rammed in one piece; it shall be inclined at an angle of 30 deg. from the vertical during pouring and shall be poured from the top. (NOTE.—The temperature of the mould immediately prior to casting should be between 10 and 40 deg. C.) The test samples shall not be mechanically worked before they are tested. When tested they must give the following results:—Maximum stress not less than 10 tons per sq. in.; elongation not less than 2 per cent.

SIR JOHN HUNTER, who recently retired from the chairmanship of Sir William Arrol & Company, Limited, Glasgow, has received from the employees a presentation in the form of a silver casket containing ivory miniatures of Sir John and Lady Hunter and an illuminated address decorated with paintings of structures with which Sir John and the firm have been associated. Sir John will continue as a director of the firm.

An Extension of the **STANTON**

Metallurgical Service

CONSULTATIONS with an expert in foundry technique who will, if desired, visit your own foundry, are a feature of the extended advisory service offered by the Stanton Company. Such visits are additional to, and quite distinct from, the ordinary calls made by sales representatives, the subjects discussed covering the whole field of foundry practice.

All queries, whether they require a personal visit or can be answered by post, will be attended to promptly and individually by a qualified metallurgical staff. The service is intended to benefit both users and producers of pig-iron by helping to improve the properties of cast-iron, so extending its field of use.

Both as ironfounders whose cast-iron products are used in all parts of the world, and as the largest producers of foundry pig-irons (for sale) in Great Britain, the Stanton Company have many years' experience of metallurgical problems. Through the medium of the advisory service this experience is placed at the disposal of the foundry industry.

Much information constantly needed by the foundryman appears in concise form in the Stanton pig-iron handbook which will gladly be sent on request. It contains useful cupola data and photographs of fractures, microphotographs and analyses of all Stanton pig-irons—including Stanton, Holwell and Rixons (W'bro') brands.

THE STANTON IRONWORKS COMPANY LIMITED
Near NOTTINGHAM

National Physical Laboratory

RESEARCH IN ENGINEERING AND METALLURGY IN 1935

The National Physical Laboratory, which was founded at Teddington in 1900, is now a large institution occupying 15 large buildings in grounds of some 50 acres, and with a staff exceeding 600. The Annual Report of the Laboratory for 1935, just issued, refers to the activities in the various departments during the year.

Engineering

During the year under review steady progress has been maintained with the various items of general research and the researches and investigations in hand for Government Departments, Research Associations and other authorities. Various items have been completed, while several new researches have been added to the programme. A considerable volume of work has also been carried out on behalf of industry, in the form of tests on a large variety of engineering components, instruments and materials of construction; the amount of work done under this heading shows a satisfactory increase over that of last year, and confirms the upward trend which became apparent about two years ago, indicating that the effects of the industrial depression were passing.

Among the investigations completed during the year may be mentioned the following. The full-scale wind pressure experiments at the Severn Bridge have been terminated; the apparatus was dismantled during the autumn of 1935. The extensive statistical investigation of the strength of welded joints, undertaken in co-operation with industry, has been completed. The research into tests on thin sheet metal has been completed and reported upon, while reports are also being prepared on impact fatigue, belts for power transmission, and that section of the research into surface conditions which relates to spring plates. This last research is now being further explored, in its technical applications, by the industry concerned. Several items on the programme of lubrication research were also completed during the year and reports have been prepared.

The new researches undertaken during the year under review include (1) a research into the fatigue properties of cast iron, undertaken for a group of steel and iron manufacturers and the Institution of Automobile Engineers; (2) extension of the work on fluid friction and heat transmission to include a study of the effect of "roughness"; (3) work on welded and other containers for the storage of propane and butane for domestic and industrial purposes; (4) the study of interference effects on the wind pressure on buildings, for which purpose a large model, measuring 9 ft. square, of a portion of the Thames frontage of London has been constructed; (5) an extensive investigation into the strength of aero-engine crankshafts, which involves the design and construction of at least two new forms of high-speed testing machines.

Several special investigations of unusual interest have been undertaken and completed during the year, of which the following may be mentioned:—(1) Study of the impact forces on the driving wheels of a railway locomotive driven at high speed; (2) investigation of thermal stresses in high-duty boiler tubes; (3) the design of vanes for smoothing out the flow of gases in factory chimneys; (4) study of the motion of big-end bearings in an internal-combustion engine; (5) various series of comparative mechanical tests on new structural steels. The investigation into fatigue phenomena has reached a stage of great interest. The task of linking up the behaviour of single crystals with that of the aggregate has been pursued by a study of specimens consisting of six crystals; it is found that the maximum resolved shear stress law still holds. The work is being extended to still smaller crystals. Further development has taken place with regard to the long-range investigation into lubrication; the work has been extended to include the study of high-pressure lubricants, an industrial problem of great importance.

Metallurgy

Work on the determination of oxides in iron and steel has been continued by both the vacuum fusion and the iodine methods. The technique of the former has been improved so that temperatures up to 2,000 deg. C. can be attained. In view of the importance of obtaining accurate thermal curves in the study of the iron-carbon and other alloys, two new pieces of apparatus have been designed and constructed. A mechanically-operated potentiometer, which is completely automatic in action, has been designed for use with the plotting chronograph.

A device for raising or lowering the temperature of a furnace in a uniform manner, making use of a photo-cell and thyratron, has been constructed for use in following thermal changes which are very small and diffuse.

An investigation of the structural changes occurring in a series of specimens of mild steel, Swedish iron, ingot iron and carbonyl iron under conditions of creep *in vacuo* has been completed, and the differences between these materials have been found to be significant. This research has also included the study of the effect of variations of carbon content over a considerable range, the results for the higher carbon steels being complicated by the formation of graphite at so low a temperature as 550 deg. C. Tests with steels of higher manganese and lower silicon contents are being undertaken to overcome this difficulty. The changes of microstructure with time at high temperatures are being studied, the steels being examined after a variety of preliminary treatments. Work on several kinds of cast iron has been completed. A comprehensive report has been made on the properties of a number of carbon and molybdenum steels at high temperatures, and on the dependence of the properties on the mode of manufacture. Further work has been done on the corrosion of steels by superheated steam, and of cast irons by flue gases.

Work on the cracking of boiler plates has shown that the typical intercrystalline cracks which are found in actual failures of boilers, due to caustic cracking, have not been produced under the conditions of the experimental plant used at the Laboratory, but non-metallic inclusions have been found to have some influence. Experiments are being made with miniature high-pressure cylinders in order to allow of rapid investigation of the critical conditions responsible for intercrystalline failure.

(*Concluded from next column.*)

evolution of air bubbles and, finally, steam bubbles on the inner surfaces of tuyeres due to superheating caused through molten iron coming in contact with the tuyere (this practically always occurs at the nose of the tuyere), the superheating at the contact point proceeding to the melting point of the tuyere-material as the air bubbles formed prevent the water from coming in contact with the tuyere walls to cool them, and so to prevent the temperature of the metal reaching the melting point. With the swiftly-flowing stream of cold water obtained in the tuyere it is obvious that such bubbles are carried away as quickly as they are formed, and cold water is always in contact with the tuyere-surface. Further, this chilling of the tuyere at the nose increases its ability to shed any molten or semi-molten iron coming in contact with the outer wall of the tuyere.

The tuyeres as supplied are hammered on the nose to increase the density, giving at the same time a smoother and harder surface which is much better able to shed molten iron as it offers the minimum facilities for adherence.

Blast-Furnace Tuyeres

NEW "DIRECT-FLOW" SYSTEM

Messrs. Ogden and Lawson of Workington have recently put on the market a "direct-flow" tuyere for blast furnaces. This has been introduced after much research and after a careful study of many failures. The new tuyere ensures a more definite and effective means for direct circulation of the cooling water around the nose through a very simple construction (Fig. 1).

The underlying principle of the Lawson "direct-flow" is the formation of a separate chamber around which the cooling water flows, and the tuyere is cast with rims round the inside walls at a suitable distance from the nose; integral with the outer rim a series of plates are cast in segment form. These plates are first projecting upwards so that the sand core can be removed, and are afterwards bent over and hammered down on to the top face of the inner rim, this being accomplished by the use of suitable tools entered through the inlet, outlet and wash-out holes. A partition is thus formed

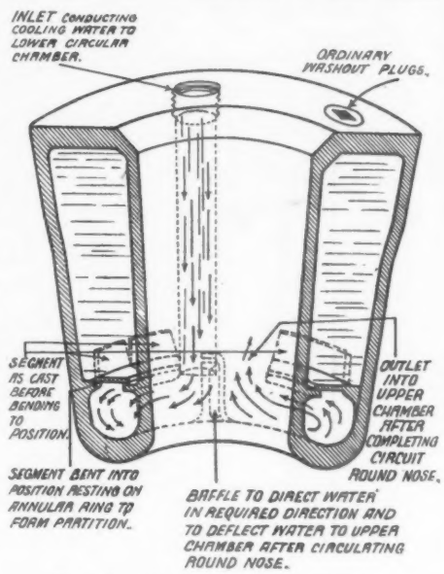
INLET CONDUCTING COOLING WATER TO LOWER CIRCULAR CHAMBER.
ORDINARY WASHOUT PLUGS.
SEGMENT AS CAST BEFORE BENDING TO POSITION.
OUTLET INTO UPPER CHAMBER AFTER COMPLETING CIRCUIT ROUND NOSE.
SEGMENT BENT INTO POSITION RESTING ON ANNULAR RING TO FORM PARTITION.
BAFFLE TO DIRECT WATER IN REQUIRED DIRECTION AND TO DEFLECT WATER TO UPPER CHAMBER AFTER CIRCULATING ROUND NOSE.

FIG. 1.—ARRANGEMENT OF TUYERE.

separating the tuyere into two distinct chambers. The inlet is then taken direct to the lower chamber and the water circulated round the nose until deflected to the main body of the tuyere by a vertical baffle which is also an integral part of the tuyere-casting. There are no loose parts or joints with the exception of the ordinary inlet pipe.

The tuyere can be operated with a smaller water supply to suit local conditions, although a plentiful supply at all times is advocated. The cooling water at its lowest temperature is taken direct to the lower chamber and positively circulated round the hottest portion of the tuyere before being free to enter the upper chamber and find its way to the outlet in the ordinary manner.

The metal plates forming the baffle are purposely cast from the outer wall of the tuyere further to assist cooling. These plates give an additional surface area of approximately 80 sq. in. equal to an increase of nearly 75 per cent. of the cooling surface (if the nose portion only is considered), and through conduction greatly assists to convey heat from the nose itself to the cooling water. Bubbles forming on the inner surfaces of the tuyere interfering with the cooling are carried away as quickly as they are formed. In this connection it has been established by a Japanese engineer that the cause of many tuyeres being burnt is due to the

(*Concluded in previous column.*)

The supplying of vitreous acid resisting enamels is a problem which has been tackled by our experts, who have studied the difficulties incurred by the usage of these enamels and have reduced them to a minimum.

Our Associated Company JAMES DAVIES (LONGTON), LTD., Ceramic Transfers, Berry Bank, Stafford Street, LONGTON, Stoke-on-Trent
('Phone: 3343 'Grams: "Ceramic, Longton, Stoke-on-Trent),
will be pleased to supply suitable vitreous transfers.

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This Week's News in Brief

Trade Talk

RICHARD THOMAS & COMPANY, LIMITED, have changed their registered office to Shell-Mex House, Strand, London, W.C.2.

BONUS CUTS made by the Mond Nickel Company, Limited, at its Clydach refinery during 1932 are to be restored in full as from May 1, 1936.

THE NOMINAL CAPITAL of Firth-Vickers Stainless Steels, Limited, has been increased by £200,000 in £1 ordinary shares beyond the registered capital of £900,000.

WILLIAM DOXFORD & SON, LIMITED, Sunderland, have received an order for a motorship of 9,200 tons from Stephen Sutton & Company, Limited, of Newcastle-upon-Tyne.

H. LEES & COMPANY, LIMITED, of Glasgow, have secured contracts for the manufacture and erection of coaling plants at Grantham and Carlisle for the L.N.E. Railway Company.

AT THE ANNUAL GENERAL MEETING of Rolls-Royce, Limited, it was announced that the firm had experienced a record year. The sum of £82,829 had been expended on land and buildings, and £172,158 on plant and machinery.

THE GENERATING STATION of British Insulated Cables, Limited, at Prescot, after 45 years of operation, has been closed down following the transfer of the electricity undertaking owned by the company, to the Liverpool Corporation.

MIRRLEES WATSON COMPANY, LIMITED, Glasgow, have secured the sole rights for the manufacture and sale in Great Britain, the Dominions, Colonies and Dependencies of the Vogel submergible electric pump, as developed by Ernst Vogel, Stockerau, Austria.

AT THE ANNUAL MEETING of the Association of Dutch Iron Foundries recently, every speaker called attention to the critical state of these works, many now being threatened with closing down. The Government is being petitioned to take steps to aid the industry.

A STRIKE OF MOULDERS at the works of George Richards & Company, Limited, of Altrincham, last week, has been settled, and the men, numbering about 60, have returned to work. The strike was a protest against several other workers having ceased to contribute to the Moulders' Union.

A FACTORY FOR THE MANUFACTURE of special-quality steel wire is being erected at Watford, on a site of about 2½ acres, by the Chiswell Wire Company, Limited. It is expected that manufacture will commence in about ten weeks' time. Bright as well as copper or zinc-coated wire will be produced.

A SHIPBUILDING CONTRACT for two twin-screw vessels, each of 10,000 tons deadweight, has been placed with the Greenock Dockyard Company by Clan Line Steamers, Limited. The machinery, consisting of a combination of reciprocating steam engines and low-pressure turbines using highly-superheated steam, will be built by John G. Kincaid & Company, Limited, Greenock.

MORE THAN £750 has been subscribed towards the endowment of a bed in the Derbyshire Royal Infirmary to the memory of the late Mr. Ian F. Panton. An indicator near the works entrance of Ley's Malleable Castings Company now shows that only £250 is needed to complete the total. It is anticipated that the scheme will be completed in about six months' time.

ON MONDAY, MAY 11, a small exhibition of electric furnaces, manufactured by Siemens-Schuckert, of Brentford, was opened at the Sheffield Corporation Electricity Department's premises at Kelham Island, Sheffield. The exhibits include the well-known duo-muffle furnace for the file industry, box-furnace with pre-heating chamber for high-speed steel, air-circulation tempering furnace with automatic air-flow reversal, electrode salt-bath furnace, and industrial water storage heater. All the furnaces are demonstrated in actual operation, and a special feature of the exhibition is the demonstrations of the new carbo-neutral salt-bath in conjunction with Imperial Chemical Industries, Ltd. With this bath, alloy steels can be bright-hardened without the slightest decarburisation at temperatures up to 1,350 deg. C. Demonstrations are also given of the new 3-pole welding set with stepless regulations. The exhibition remains open until May 16.

IT IS ANNOUNCED that, by an agreement which became operative on April 30, R. A. Lister & Company, Limited, of Dursley, and Blackstone & Company, Limited, of Stamford, will in future co-operate. Under the agreement Listers have acquired a substantial holding in the Blackstone firm, and Mr. Percy Lister, Mr. R. B. Lister and Mr. A. E. Mellerup join Mr. Ernest Blackstone, Mr. Harold Blackstone and Mr. Tom Price on the board of Blackstone & Company. Mr. Percy Lister has been appointed chairman. While the two concerns will continue to operate separately, the policy of the companies will be to co-ordinate the productive resources of their respective plants to the maximum. Both firms have already a substantial export trade, which, it is believed, will be materially increased by their association. The firm of Blackstones, founded 99 years ago, is one of the oldest in the British engineering industry. R. A. Lister & Company, Limited, was founded 69 years ago by the late Sir Ashton Lister.

Contracts Open

London, W., June 3.—Cast steel gully gratings and frames, for the Town Council. The Borough Engineer, Municipal Offices, Acton, W.3.

Rolleston, May 20.—1,150 yds. of 3-in. cast-iron water mains (class C spun pipes), for the Southwell Rural District Council. Sands & Walker, consulting engineer, Milton Chambers, Nottingham.

Slough, May 27.—Two groups of pumping plant, with motors, pipe connections, valves, switchgear, etc., for the Urban District Council. G. B. Kershaw & Kaufman, engineers, 9, Victoria Street, Westminster, S.W.1. (Fee £5, returnable.)

Worksop, May 18.—Two electrically-operated vertical spindle centrifugal pumping units to lift 2,000 galls. per min. each against a total head of 260 ft., for the Town Council. Mr. C. O. Allsopp, borough engineer, Town Hall. (Fee £4 4s., returnable.)

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

P. Wilkinson & Sons, Limited, 14-19, Tottenham Mews, Tottenham Street, London, W.1.—Capital, £5,000. Aluminium, brass and iron founders, etc. Directors: S. E. and S. W. Washbourn.

Obituary

THE DEATH HAS OCCURRED of Mr. Joseph Short, formerly works manager at Harrison, McGregor & Company's Albion Ironworks, Leigh, Lancs. He was 61 years of age and had served with the firm for 50 years, retiring last October.

MR. C. S. D. MACLEAN, who was chief bridge engineer to the L.M.S. Railway Company for over 20 years, has died at the age of 70. Mr. Maclean was responsible for all the company's bridges between Carlisle and London, and Lincoln and Swansea. He designed many bridges, the last two being at Ambergate.

THE DEATH HAS OCCURRED of Mr. J. R. Winpenny, who for many years was secretary of the North of England Iron and Steel Manufacturers' Association and the Steel Ingot Makers' Association. He retired recently from the secretaryship of the Royal Exchange, Middlesbrough, and had also acted as employers' secretary on the board of arbitration in connection with the steel industry. Mr. Winpenny was in his 88th year.

THE DEATH OCCURRED, on May 5, of Colonel Robert Maclaren, T.D., D.L. Col. Maclaren, who was in his 75th year, was the son of the late Robert Maclaren, a prominent iron-pipe founder, with whom he was associated in business. Col. Maclaren was chairman and managing director of the Eglinton Foundries at Port Eglinton, a director of Macfarlane Strang & Company, Limited, of Lochburn Iron Works, Glasgow, and a former chairman of the Royal Exchange, Glasgow.

Personal

MR. AND MRS. J. KERSHAW, of Birkdale, Southport, celebrated their golden wedding on May 9. Mr. Kershaw was formerly in business as an iron-founder at Union Foundry, Moor Street, Bury, Lancs, for over 30 years.

MR. H. M. ABEL, chairman of directors of Abel, Lemon & Company Pty., Limited, of Australia, whose London office is at 74, Great Tower Street, E.C.3, arrived in London on May 8. This firm, which has branches throughout the whole of Australia, has specialised for many years in supplying raw materials for the foundry trade. Mr. Abel is accompanied by his son, Mr. E. V. Abel.

MR. G. ERNEST WELLS, until recently a director of Edgar Allen & Company, Limited, of Sheffield, has now joined the board of Kryn & Lahy (1928), Limited, of Letchworth. Mr. Wells' connection with Edgar Allen's dates from 1900, and for 17 years he was a director, occupying also the position of foundry manager. Amongst his many activities Mr. Wells was responsible for the design of the entire foundry and its equipment. During the war Mr. Wells acted as controller of the whole of the iron and steel foundries in Great Britain on behalf of the Minister of Munitions. His many friends in this country and abroad will wish him all success in his new enterprise.

MR. G. E. WELLS.

MR. J. A. E. WELLS, foundry manager of Edgar Allen & Company, Limited, Imperial Steelworks, Sheffield, and Dr. F. C. Lea, Dean of the Faculty of Engineering, Sheffield University, have accepted an invitation to join the board of directors of Edgar Allen. Mr. Wells has been connected with the firm since 1907, when he joined the laboratory staff. He then went into the foundry, and afterwards supervised foundry deliveries and orders for steel castings which had to conform to important specifications. Eventually he took over the moulding and core-making departments, and a little later was responsible for the practical side of the steel-foundry work. Dr. F. C. Lea, O.B.E., has a wide and specialised knowledge of engineering, and has done much research work into the materials most suitable for aircraft and the development of all-metal machines. He has written a number of standard books on hydraulics, and contributed technical Papers to many scientific societies. He is chairman of the Welding Research Committee of the Institution of Mechanical Engineers.

Wills

WATERHOUSE, F. H., managing director of Fotherby & Company, Limited, iron-founders and engineers, Wakefield ... £5,494

WHILE, AUGUSTUS, principal of David Caird, Limited, ironfounders, Barrow-in-Furness, and a director of the Charcoal Iron Company, Limited, Blackbarrow £22,051

VESSEY, WYNFORD, of Sheffield, a director of John Vessey & Sons, Limited, steel manufacturers, and secretary and director of Matthias Spencer & Sons, Limited, mining-tool manufacturers, etc. £9,133

Forthcoming Events

MAY 26.

Institution of Civil Engineers:—Ordinary Meeting: "Recent Developments in Metallurgy and their Influence on Engineering," Paper by M. Eugene Shneider, at 6 p.m.

MAY 27.

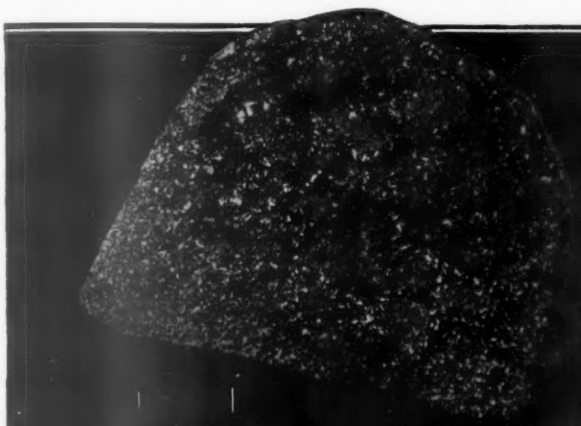
Manchester Association of Engineers:—Visit to the works of Mather & Platt, Limited, Park Works, Newton Heath, at 2.30 p.m.

Institute of British Foundrymen

JUNE 9-12.

Annual Conference in Scotland.

DORMAN LONG



Manufacturers of FOUNDRY, BASIC and HEMATITE qualities. Delivery from stock. Booklet giving analyses, etc., will be sent on request.

DORMAN LONG & CO. LTD.,
MIDDLESBROUGH

AGENTS IN SCOTLAND:
MESSRS. J. & A. McMORLAND,
40 ST. ENOCH SQUARE, GLASGOW

PIG IRON

WARNER Special PIG IRONS

- Warner C.B.R.
and
- Low Carbon Cylinder
(FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
- Low Carbon Malleable
(FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

Typical Cylinder Pig Iron Specification

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

Typical Malleable Pig Iron Specification

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

WARNER & CO. LTD
CARGO FLEET MIDDLESBROUGH

Raw Material Markets

New business in the steel trade has not increased as a result of the heavy-steel makers' decision to maintain current prices until the end of June. This is due to the producers not being in a position to accept further commitments for delivery before July. Steelmakers are working to capacity, and there is every reason to believe that these conditions will prevail for some considerable time. In order to counteract the shortage of home-produced pig-iron, 150,000 tons are to be imported from India over a period of 15 months, while negotiations are in progress with Russian exporters for the importation of a similar quantity from that country.

Pig-Iron

MIDDLESBROUGH.—All stocks of Cleveland foundry iron have now been absorbed, and, as no furnaces are engaged in making this quality of iron, trade has been completely suspended. Regular consumers are still able to obtain supplies from other areas, but Midland makers have a decreasing surplus to offer and Indian pig-iron is now being utilised by a few Cleveland users. It is hoped to resume production of Cleveland pig-iron at the end of the month, but any iron that becomes available will, of course, be used for the reduction of existing contract arrears. New business will only be accepted for delivery in the second half of the year, when prices will be higher by 5s. per ton. Current prices are nominal only, the accepted quotations for No. 3 G.M.B. being 70s. per ton in the Middlesbrough and Falkirk areas, 72s. on the North-East Coast and 73s. on Clydeside.

All available supplies of hematite are being absorbed. Makers have small stocks, but it is stated that these are sold for early delivery. Business for the second half of the year does not, as yet, amount to any substantial tonnage, but it is expected that users will not delay much longer in placing orders. Any contracts that may be transacted for delivery during this period contain stipulations to the effect that the iron will be paid for at the prices ruling at the date of delivery.

LANCASHIRE.—Any new business that has been transacted recently has only involved small parcels and makers refuse to guarantee delivery at any fixed time. Deliveries continue to be on a satisfactory scale, but users still have cause for complaint as regards their lateness. Textile-machinists have improved order-books, while the light-castings trade and also the machine-tool makers, the heavy electrical engineers, the jobbing foundries and a number of speciality foundries are taking up larger tonnages of iron. Present values of Staffordshire, Derbyshire and Lancashire brands of No. 3 foundry iron, equal to Derbyshire, for delivery to Lancashire foundries before the end of June, are largely nominal at 78s. per ton, with Northants at 76s. 6d. Prices for delivery after June 30 are at a premium of 5s. per ton. For delivery to Widnes and Runcorn recent contracts have been made at a rate which was 1s. 6d. per ton below that to other towns, but this position has been adjusted and the price is now the same for delivery throughout the county. Scottish No. 3 iron, for delivery equal to Manchester, is quoted at around 89s. per ton, with hematite on the basis of 85s. 6d. per ton for West Coast material and from 84s. 6d. to 85s. for East Coast, both inclusive of delivery in the Manchester district.

MIDLANDS.—The light-castings manufacturers continue to press producers of ordinary foundry pig-iron for deliveries against contracts. Stocks of pig-iron are very low and some furnaces are in arrears with deliveries. Current Association prices for delivery up to the end of June are 72s. 6d. per ton for Northants No. 3 and 75s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, delivered Birmingham and Black Country stations. Forge pig-iron for foundries is 3s. and for ironworks 5s. less than the price of foundry iron, and supplies are becoming less plentiful. Special irons are in heavy demand and quotations range from 80s. to 87s. 6d. for medium-phosphorus iron, 92s. 6d. to 100s. for low-phosphorus, including Scottish, and £6 10s. to £7 15s. for special refined iron. Quotations for hematite are only available for delivery up to the end of July, West Coast mixed numbers being at £4 8s. 6d., East Coast No. 3 at £4 7s. 6d., and Welsh mixed numbers at £4 7s., delivered stations in this area, plus 1s. 6d. for delivery into works in 10-ton lots.

GLASGOW.—Difficulty continues to be experienced in procuring sufficient supplies of pig-iron to satisfy users' full requirements. Supplies of Cleveland foundry iron are very scarce and Midland iron is being used to supplement deliveries, together with Scottish high-phosphorus iron. Imports from the Continent have now ceased. The official minimum of 79s. f.o.t. furnaces for Scottish No. 3 foundry iron still operates, with 2s. 6d. extra for No. 1. Makers of light castings are being held up by the shortage of pig-iron. Nominal quotations for No. 3 Cleveland remain at 70s. f.o.t. Falkirk and 73s. f.o.t. Glasgow. The demand for hematite and basic iron for the steelworks is heavy. Steelmaking irons are still officially quoted at 77s. for East Coast, West Coast and Scottish hematite, and 72s. 6d. (less 5s. rebate) for British and Indian basic, delivered steelworks, but the prices are nominal only.

Coke

There is no easing of the position on the foundry-coke market and it is considered extremely unlikely that lower price levels will come into operation for supplies delivered up to the end of the year. For delivery in Birmingham and district best Durham coke ranges from 41s. 6d. to 43s., and Welsh coke from 38s. 6d. to 50s. per ton.

Steel

Active conditions continue to rule in the British steel industry, and many departments of the producing works are well supplied with orders for delivery into the third quarter of the year, states the official report of the London Iron and Steel Exchange. For the past week or two the volume of new business reaching the manufacturers has been rather light, but this is regarded as a natural consequence of the previous heavy buying. The steelworks are using large quantities of basic iron and supplies in this department are none too plentiful. The recent imports of semi-finished material from the Continent afforded some relief to the tightness which has ruled for so long in this section, but consumers are not finding it easy to obtain all the steel they need. The British producing works have sold their output for a long time to come, and in many cases are behindhand in deliveries. Business in finished steel has been rather quiet, but specifications are reaching the works at a satisfactory rate and a heavy tonnage is passing into consumption. The requirements of the consuming trades have been well maintained, and it seems probable that the present heavy output will be continued.

Scrap

Further imports of scrap material have arrived in the Cleveland area, but supplies are still below the demand. Users are refusing to pay more than 57s. 6d. per ton for home supplies of heavy melting steel, delivered works, while machinery cast-iron scrap has a good demand at 65s. Foundry metal is at a minimum of 62s. 6d. Little change has occurred in the conditions of the Midland market, all qualities of scrap being in heavy demand. Heavy steel in furnace sizes is at 52s. 6d. to 55s., while 52s. 6d. is offered for mixed iron and steel. Heavy machinery metal in handy sizes is at 70s., good heavy at 65s., and clean light at 52s. 6d. to 55s. Short, heavy steel, suitable for foundry purposes, is at 67s. 6d. per ton delivered works. Rather quieter conditions have obtained on the Lancashire market. Good machinery metal is quoted at 67s. 6d., including delivery to Lancashire foundries, while heavy melting steel scrap is easier at 52s. 6d. to 55s., delivered Sheffield basis. Wrought-iron scrap is at 65s. per ton. Some of the consumers on the Scottish market have suspended deliveries and as a result the turnover has not been so large during the past week, although prices have not eased. Large tonnages of imported material continue to arrive in this area. Heavy, mild-steel melting scrap is at 57s. 6d., with heavy basic or heavy iron and steel scrap mixed, at 52s. 6d. Heavy machinery cast-iron scrap is less active, but the price is firm at 70s. to 72s. 6d., in pieces not exceeding 1 cwt. and suitable for cupolas, while ordinary cast-iron scrap, to the same specification, is about 5s. per ton less, delivered f.o.t. consumers' works.

Metals

Copper.—Buying has been on a fairly good scale in this country, armament firms being well to the fore in this respect. The undertone of the market is firm and consumption is quite satisfactory. The European market is dominated by an abnormally large French consumption. In the United States the undertone is firm, but buying is on a low scale. New copper ore deposits have been found near Velusin, in Jugoslavia. Japan's consumption of copper in 1935 reached the record high figure of 134,170 metric tons. Of this total 65,300 tons were imported. Japan now ranks as the fourth largest consumer of copper in the world.

Daily market prices :—

Cash.—Thursday, £36 18s. 9d. to £37; Friday, £36 13s. 9d. to £36 15s.; Monday, £36 17s. 6d. to £36 18s. 9d.; Tuesday, £36 15s. to £36 16s. 3d.; Wednesday, £36 11s. 3d. to £36 12s. 6d.

Three Months.—Thursday, £37 5s. to £37 6s. 3d.; Friday, £36 18s. 9d. to £37; Monday, £37 3s. 9d. to £37 5s.; Tuesday, £37 1s. 3d. to £37 2s. 6d.; Wednesday, £36 16s. 3d. to £36 17s. 6d.

Tin.—This has been a quiet market during the week and little new business has been transacted. Similar conditions are reported on the Continent and in the United States. The future must be regarded as uncertain. A meeting of the International Tin Committee is to be held shortly, when the quota will be reviewed in the light of the Bolivian deficiency. The question of Bolivia's capability or otherwise of fulfilling the 85 per cent. quota is still a question of considerable dubiety in tin circles.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £204 5s. to £204 15s.; Friday, £203 10s. to £203 15s.; Monday, £204 to £204 10s.; Tuesday, £204 to £204 5s.; Wednesday, £203 15s. to £204 5s.

Three Months.—Thursday, £198 10s. to £199; Friday, £197 10s. to £197 15s.; Monday, £197 15s. to £198; Tuesday, £197 10s. to £197 15s.; Wednesday, £197 17s. 6d. to £198.

Spelter.—Steady conditions have prevailed in this market. In some quarters a favourable view is taken regarding the Cartel negotiations. Little is officially known, but it is believed that considerable progress has been made in this respect. However, many rumours to the contrary are in circulation, one going so far as to infer that discussions have definitely broken down. An official announcement is awaited. Buying has not been heavy in this country; brass-makers have again been the leading consumers. April statistics for the United States market show that stocks have risen by some 1,000 tons. The tone of the market is stated to have remained firm.

Official quotations were as follow :—

Ordinary.—Thursday, £14 16s. 3d.; Friday, £14 11s. 3d.; Monday, £14 10s.; Tuesday, £14 12s. 6d.; Wednesday, £14 7s. 6d.

Lead.—Cable makers in this country have again had very satisfactory requirements and they, together with other consuming industries, have taken up considerable tonnages during the past week.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 13s. 9d.; Friday, £15 7s. 6d.; Monday, £15 7s. 6d.; Tuesday, £15 5s.; Wednesday, £15 2s. 6d.

IDAHO PINE
YELLOW PINE

PRIME & PATTERN GRADES
½" to 3" thick
Width up to 24" wide
All free of centre heart and shake

CHETHAM TIMBER
Co., Ltd.,
70, FINSBURY PAVEMENT,
LONDON, E.C.2
Metropolitan 7418

TOR ROCK SAND

It is now possible to obtain from a deposit in the Midlands, a moulding sand possessing all the excellent characteristics of the Scottish Rock sands. This sand we have called Tor Rock Sand. It is well bonded, coarse in grain, and highly permeable.

The advantage this sand offers to iron founders in the Midlands and the South is obvious. Railway rates, which represent a high proportion of the cost of moulding sand when delivered are reduced considerably. Please write for full particulars and samples.

CHEMICAL ANALYSIS

Silica	86·8 %
Ferric Oxide	1·43%
Alumina	7·6 %
Lime	·22%
Magnesia	·18%
Titanic Oxide	·18%
Alkalies	1·8 %
Loss on ignition	1·6 %

MECHANICAL ANALYSIS

Very Coarse Sand (+ 1 mm)	16·5%
Coarse Sand (+·5 mm—1 mm)	16·0%
Medium Sand (+·25 mm—·5 mm)	11·0%
Fine Sand (+ ·1 mm—·25 mm)	30·0%
Silt Grade (+ ·01 mm—·1 mm)	7·0%
Clay Grade (—·01 mm)	19·5%

GENERAL REFRACTORIES Ltd.,

Genefax House, Sheffield.

Telephone: Sheffield 31113 (6 lines). Telegrams: "Genefax, Sheffield."

London Office:
Russell House,
Adelphi, W.C.2.
Telephone: Temple Bar 7361.
Telegrams:
"Genefax, Rand-London."

Scottish Office:
156, St. Vincent St.,
Glasgow.
Telephone: 5250.
Telegrams:
"Genefax, Glasgow."

South Wales Office
11, Wind St.,
Swansea.
Telephone: 3080
Telegrams:
"Genefax, Swansea."

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION.

RAW MATERIALS—PRICE LIST

(Wednesday, May 13, 1936)

COPPER

	£ s. d.
Standard cash	36 11 3
Three months	36 16 3
Electrolytic	40 15 0
Tough	39 5 0
Best selected	39 15 0
Sheets	70 0 0
India	50 10 0
Wire bars	41 5 0
Ingot bars	41 5 0
H.C. wire rods	44 15 0
Off. av. cash, April	37 0 2½
Do., 3 mths., April	37 5 11½
Do., Sttlmnt., April	37 0 1½
Do., Electro, April	41 6 8½
Do., B.S., April	40 15 0
Do., wire bars, April	41 10 9
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	6½d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8½d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8d.
Wire	7½d.
Rolled metal	7½d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£ s. d.
Standard cash	203 15 0
Three months	197 17 6
English	204 0 0
Bars	205 0 0
Straits	205 10 0
Australian (nom.)	203 15 0
Eastern	202 5 0
Banca	205 5 0
Off. av. cash, April	209 9 0½
Do., 3 mths., April	203 16 3
Do., Sttlmt., April	209 8 0

SPELTER

	£ s. d.
Ordinary	14 7 6
Remelted	13 5 0
Hard	11 5 0
Electro 99.9	16 10 0
English	15 2 6
India	12 5 0
Zinc dust	19 10 0
Zinc ashes	4 5 0
Off. aver., April	15 5 1½
Aver. spot, April	15 3 7½

LEAD

	£ s. d.
Soft foreign ppt.	15 2 6
Empire (nom.)	16 0 0
English	17 5 0
Off. average, April	16 3 3½
Average spot, April	16 1 11½

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

Zinc sheets, English 24	10 0 to 25 0 0
Do., V.M. ex-whse. 24	10 0 to 25 0 0
Rods	27 0 0

ANTIMONY

English	69 10 0 to 70 10 0
Chinese, ex-whse.	56 0 0
Crude, c.i.f.	28 0 0

QUICKSILVER

Quicksilver	11 15 0 to 12 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 0 0 to £22 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 10 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose £11 5	0 to 11 15 0
76/80% packed £12 5	0 to 12 15 0
76/80% export	(nom.) £10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated. basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to $\frac{1}{16}$ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	3 5 0	to 3 6 0
Mixed iron and steel	3 0 0	to 3 2 6
Heavy cast iron	2 15 0	to 3 0 0
Good machinery	3 2 6	to 3 5 0
Cleveland—		
Heavy steel	2 17 6	
Steel turnings	2 0 0	
Heavy cast iron	3 2 6	
Heavy machinery	3 5 0	
Midlands—		
Light cast-iron scrap	2 12 6	to 2 15 0
Heavy wrought iron	3 7 6	to 3 10 0
Steel turnings	2 2 6	
Scotland—		
Heavy steel	2 17 6	
Ordinary cast iron	3 5 0	to 3 7 6
Engineers' turnings	2 2 6	
Cast-iron borings	1 17 6	to 1 18 6
Wrot-iron piling	3 10 0	
Heavy machinery	3 10 0	to 3 12 6

London—Merchants' buying prices, delivered yard.

Copper (clean)	30 0 0
Brass	19 10 0
Lead (less usual draft)	14 0 0
Tea lead	9 0 0
Zinc	9 0 0
New aluminium cuttings	74 0 0
Braziery copper	27 0 0
Gunmetal	28 0 0
Hollow pewter	155 0 0
Shaped black pewter	116 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	72/6
,, No. 3	70/-
,, at Falkirk	70/-
,, at Glasgow	73/-
,, No. 4	69/-
Forge No. 4	69/-
Hematite No. 1	77/-
Hematite M/Nos.	76/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	77/-
,, d/d Birm.	88/6
Malleable iron d/d Birm.	120/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	72/-
,, No. 3 fdry.	75/-
Northants forge	69/6
,, fdry. No. 3	72/6
,, fdry. No. 1	75/6
Derbyshire forge	72/-
,, fdry. No. 3	75/-
,, fdry. No. 1	78/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
,, No. 3, f.o.t.	79/-
Hem. M/Nos. d/d	77/-
Sheffield (d/d district)—	
Derby forge	69/6
,, fdry. No. 3	72/6
Lincs forge	69/6
,, fdry. No. 3	72/6
W.C. hematite	90/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	78/-
Staffs fdry. No. 3	78/-
Northants fdry. No. 3	76/6
Cleveland fdry. No. 3	78/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	89/-
Clyde, No. 3	89/-
Monkland, No. 3	89/-
Summerlee, No. 3	89/-
Eglinton, No. 3	89/-
Gartsherrie, No. 3	89/-
Shotts, No. 3	89/-

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	10 2 6	
Nut and bolt iron	8 10 0	to 9 0 0
Hoops	11 0 0	and up.
Marked bars (Staffs) f.o.t.	12 10 0	
Gas strip	11 0 0	and up.
Bolts and nuts, ¾ in. × 4 in.	15 15 0	and up.
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ¾ in. (Untested)	9 1 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 10 0	
Hoops (Staffs)	9 16 0	
Black sheets, 24g. (4-t. lots)	11 10 0	
Galv. cor. shts. (,,)	13 10 0	
Galv. flat shts. (,,)	14 0 0	
Galv. fencing wire, 8g. plain	15 0 0	
Billets, soft	5 17 6	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 15 0	to 6 5 0
Tin bars	5 15 0	to 6 5 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	11½d.
Tubes	14d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	28.00
Sheet bars	28.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.85
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	20/- to 22/-
Durham foundry	23/6 to 24/6
,, furnace	21/-
Scotland, foundry	30/-
,, furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box	18/9
,,	28×20 ,,	37/6
,,	20×10 ,,	27/-
,,	18¾×14 ,,	19/6
C.W.	20×14 ,,	15/9 to 16/3
,,	28×20 ,,	34/3
,,	20×10 ,,	23/-
,,	18¾×14 ,,	15/9 to 16/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

		£ s. d.	
May	7 ..	36 18 9 dec.	1/3
,,	8 ..	36 13 9 ,,	5/-
,,	11 ..	36 17 6 inc.	3/9
,,	12 ..	36 15 0 dec.	2/6
,,	13 ..	36 11 3 ,,	3/9

Electrolytic Copper

		£ s. d.	
May	7 ..	41 5 0 dec.	2/6
,,	8 ..	40 15 0 ,,	10/-
,,	11 ..	41 0 0 inc.	5/-
,,	12 ..	41 0 0 No change	
,,	13 ..	40 15 0 dec.	5/-

Standard Tin (cash)

		£ s. d.	
May	7 ..	204 5 0 dec.	15/-
,,	8 ..	203 10 0 ,,	15/-
,,	11 ..	204 0 0 inc.	10/-
,,	12 ..	204 0 0 No change	
,,	13 ..	203 15 0 dec.	5/-

Tin (English ingots)

		£ s. d.	
May	7 ..	204 10 0 dec.	15/-
,,	8 ..	203 10 0 ,,	20/-
,,	11 ..	204 5 0 inc.	15/-
,,	12 ..	204 5 0 No change	
,,	13 ..	204 0 0 dec.	5/-

Spelter (ordinary)

		£ s. d.	
May	7 ..	14 16 3 dec.	1/3
,,	8 ..	14 11 3 ,,	5/-
,,	11 ..	14 10 0 ,,	1/3
,,	12 ..	14 12 6 inc.	2/6
,,	13 ..	14 7 6 dec.	5/-

Spelter (Electro, 99.9 per cent.)

		£ s. d.	
May	7 ..	16 18 9 dec.	1/3
,,	8 ..	16 13 9 ,,	5/-
,,	11 ..	16 12 6 ,,	1/3
,,	12 ..	16 15 0 inc.	2/6
,,	13 ..	16 10 0 dec.	5/-

Lead (soft foreign, prompt)

		£ s. d.	
May	7 ..	15 13 9 dec.	3/9
,,	8 ..	15 7 6 ,,	6/3
,,	11 ..	15 7 6 No change	
,,	12 ..	15 5 0 dec.	2/6
,,	13 ..	15 2 6 ,,	2/6

Lead (English)

		£ s. d.	
May	7 ..	17 15 0 dec.	5/-
,,	8 ..	17 10 0 ,,	5/-
,,	11 ..	17 10 0 No change	
,,	12 ..	17 5 0 dec.	5/-
,,	13 ..	17 5 0 No change	

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1901	8 0 0	7 10 0	7 5 0	7 0 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 15 0	6 17 11
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	6 0 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 8	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	9 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 8	10 2 8	10 2 8	10 0 6	10 3 9	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	—	—	—	—	—	—	—	—	—

* No quotation available owing to strike.

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All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

FOUNDRY Manager desires re-engagement; 20 years complete control in the manufacture of marine engineering, general, woodworking machines, electrical, internal-combustion engines, pumps, valves, chests, etc. Practical moulder; many years' experience as Representative, buying, selling and estimating. Further experience in light castings by machine moulding, hydraulic, squeeze, hand-ram and sand-slinger. Forceful, tactful, energetic and good organiser. Good cupola practice.—Box 720, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOUNDRYMAN with many years' experience as representative and traveller, desires similar position with any foundry or foundries, or would consider position as Representative with any firm producing or selling foundry materials or requisites of any description.—Box 722, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

ASSISTANT Foundry Foreman wanted with experience in light steel castings, used to modern methods and some technical knowledge. An excellent opportunity with prospects for right man. Write giving age, experience, and salary required, to Box 708, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

MECHANICAL Engineer required to maintain and extend manufacturers' plant and foundry. Applicants must state experience, if any, of each of the following:—(1) Mechanical sand-handling equipment and iron-melting plant. (2) Hydraulic and compressed-air moulding machines. (3) High-pressure sand blasting. (4) Oil-fired porcelain-enamelling muffles. (5) Conveyor japanning ovens. (6) Stamping and drawing presses and sheet-metal working machinery. (7) Dust-extracting plants. (8) Welding machines (all types). (9) General precision tools. (10) Building repairs. Write giving details categorically, and positions occupied; age and salary required.—Box 712, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

SUPERVISOR or Foreman for London Bronze Foundry (Engineering). Good experience and organiser, with sound practical knowledge sand conditioning, green and oil sand, chill stick, hand and machine moulding, etc. Write fully and state salary expected.—Box 728, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WORKING Chargehand required for a small foundry situated in South Midlands; good position for a capable man who can get results; must have experience in pneumatic and hand machines in addition to hand moulding in cast iron and non-ferrous metal. State age and wages to Box 718, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PATENT

THE proprietor of British Patent No. 370,976, dated January 12, 1931, relating to "Improvements in making Blooms, Slabs and Billets," is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patent and ensuring its practical working in Great Britain.—Inquiries to B. SINGER, Steger Building, Chicago, Illinois.

MACHINERY

WANTED.—Second-hand Blasting Outfit, complete except for motor, operating about 80 lbs. pressure, suitable for sand-blasting small castings. State full particulars and price.—Box 716, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

WANTED.—Converter Shell approximately 5 ft. diameter for side-blown Bessemer in any condition.—Details to Box 714, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

NEARLY new Sklener Midget Brass-Melting Furnace with oil-fuel tank and fittings; cheap price to clear.—Box 724, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOR SALE.—Three "Ajax" No. 9 Turnover Moulding Machines and one "Ajax" Stripping-Plate Moulding Machine with vibrator, complete with all accessories. Can be seen under working conditions. Price £50 each.—THOMAS BROADBENT & SONS, LIMITED, Huddersfield.

NEW Dwarf Cupola, to melt 10 to 15 cwts. per hr. New Worm-geared Ladles, 5 tons, 25 cwts., 15 cwts. and 10 cwts. capacity. Ungeared Ladles, 15 cwts. and 10 cwts. capacity. Improved Cupola Spark Arresters.—T. DAVIES & SON, West Gorton, Manchester.

Tilghman Sandblast Barrel Plants; barrel sizes—60 in. x 40 in.; 36 in. x 20 in.; 20 in. x 30 in.

Tilghman Sandblast Cabinet Plants; 4 ft. 6 in. and 3 ft. 6 in. square (one for high pressure 70 lbs. per sq. in.); also small Cabinet 30 in. dia.

All complete with Air Compressors, etc.

Pneulec Royer Sand Thrower, size No. 1.

Six Osborne Pneumatic Jolt Press Moulding Machines, size 75J.

Three Mumford Yoke Headpress Pneumatic Moulding Machines.

Two Herbert Whizzer Sand Disintegrators.

Two Brealey Type ditto.

Heavy Double-ended Grinding Machines by Rowlands, Luke & Spencer, etc.

Hand Moulding Machines by Adaptable Darling & Sellars, Pridmore, Samuelson, etc.

500 Electric Motors, Dynamos, Rotary Converters, etc.

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Two Pneu. JAR-RAM MOULDING MACHINES (Pneu. Eng'g Appliances); table 36" x 22".

"Pridmore" Pneu. Rollover MOULDING MACHINE; type EV; two air cyls. 10¼" dia. x 12" stroke; take boxes 3' 6" x 2'.

Three LANCS. BOILERS; 30' x 8'; 140 lbs. w.p.

5,000' riveted TUBING; 20" dia. x ¼" plate.

Write for "Albion" Catalogue.

'Grams: "Forward." 'Phone: 23001 (10 lines).
ALBION WORKS, SHEFFIELD.

MISCELLANEOUS

WANTED.—Iron Foundry to supply small cast wheels by mass production. Full particulars.—Box 726, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

FOR SALE.—One 4-ton Foster Steel Tipping Ladle, top and bottom pourer. One Evans 3-ton Tipping Ladle, 42 in. deep, 37 in. tapering to 29 in. dia. Bogey for carrying ladles suitable for track 2 ft. 6 in. between rails.—Apply: E. HIND, Imperial Works, South Bank-on-Tees.

MISCELLANEOUS—*Continued*

FOR SALE.—10,000 tons of Ganister, best quality; also High-Silica Moulding Sand.—For particulars—
R. SCOTT,
Derwent Quarries,
Consett, Co. Durham.

'Phone: 287 SLOUGH

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Twelve reconditioned Tilghman Barrel Plants, sizes 12"×18" to 60"×40". Low prices.
New 8' cube Room Plant complete, price **£160.**
Good 6' square cast-iron Room Plant complete, price **£100.**
Complete 12' square Room Plant for sale cheap.

CUPOLAS

Two new 30" diam. CUPOLAS with A.C. Fans

PLEASE WRITE FOR OUR NEW CATALOGUE GIVING DETAILS OF OVER 100 BARGAINS IN MODERN FOUNDRY PLANT FOR IMMEDIATE DELIVERY.

ALEX. HAMMOND, *Foundry Machinery Merchant,*
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